United Planters' Association of
Southern India

SCIENTIFIC DEPARTMENT

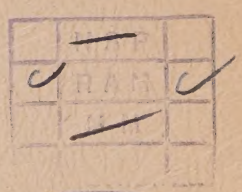
(TEA SECTION)

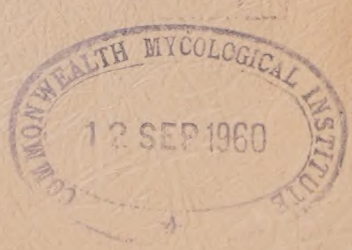
ANNUAL

ADMINISTRATION REPORT

FOR

1959-1960





NOTE:

Specimens for laboratory examination should be sent by *unregistered* post to

The Officer-in-Charge,
UPASI Tea Experiment Station,
Devarshola P. O.,
Nilgiris.

In the case of specimens too bulky to send by post, they should be sent by rail to Ootacamund and the Rail Receipts or parcel Way Bills sent to

The Rajalakshmi Motor Service,
Ootacamund,

for collection and forwarding to Devarshola.

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1959-1960

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TEA PRODUCT SUB-COMMITTEE

(Upto August 1959)

Mr. P. S. M. Molyneux	*Chairman—Resigned June 1959*
Mr. E. J. C. Menzies	*Chairman—From July 1959*
Mr. A. M. B. Clarke	*Member—Resigned Februarg 1959*
Mr. C. H. S. London	,, *From March 1959*
Mr. M. M. Varghese, (*President, UPASI*)	*Ex-Officio*
Mr. L. W. Russell, (*Vice-President, UPASI*)	*Ex-Officio*

TEA PRODUCT SUB-COMMITTEE

(From September 1959)

Mr. C. Stewart	*Chairman—Resigned December 1959*
Mr. J. R. Henshaw	*Chairman—From December 1959*
Mr. C. H. S. London	*Member*
Mr. W. Wilson Mayne *(President, UPASI)*	*Ex-Officio*
Mr. M. M. Varghese, (*Vice-President, UPASI*)	*Ex-Officio*

AD-HOC RESEARCH EXPANSION SUB COMMITTEE

(From September 1959)

All Members of the Tea Product Sub-Committee and

Mr. P. W. Davidar	*Member*
Mr. E. J. C. Menzies	,,
Chairman, Tea Board	,,

SCIENTIFIC DEPARTMENT

Technical Staff

Mr. S. Ananda Rau, M.Sc.	*Chief Scientific Officer*
Mr. V. Jayraman, B A., B.Sc., (Ag.)	*Soil Chemist*
Dr. K. S. Venkataramani, M.Sc., Ph.D., F.B.S.	*Botanist*
Dr. C. S. Venkata Ram, M Sc., Ph.D.	*Plant Pathologist*
Mr. N. R. Ananthakrishnan, B.Sc., (Hons.) Ag., A.I.A.R.I.	*Entomologist*

Office Staff

Mr. K. I. Abraham	*Clerk—Devarshola*
Mr. S. Kailasanathan	*Clerk—Coonoor.*
Mr. M. Mariadas	*Attender—Coonoor.*

Field Staff

Mr. E Powell	*Field Recorder*

Laboratory Attenders

Mr. P. Sankaran Nair
Mr. K. Madhavan Chetty
Mr. Ahmed Kutty

United Planters' Association of Southern India.

ANNUAL REPORT OF THE UPASI SCIENTIFIC DEPARTMENT

TEA SECTION

For 1st April 1959—31st March 1960

REPORT OF THE CHIEF SCIENTIFIC OFFICER

PART I—ADMINISTRATION

The Chief Scientific Officer continued to have his headquarters at Coonoor and Mr. V. Jayaraman, Soil Chemist, was in charge of the Tea Experiment Station, Devarshola.

Dr. K. S. Venkataramani, Botanist, who had resigned and left the service of the UPASI in January 1959 made a request subsequently to return to the same post which the Committee viewed favourably. He rejoined duty in December 1959.

Mr. N. R. Ananthakrishnan was appointed to the post of Entomologist in June 1959. After a period of 3 months at Devarshola Experiment Station, he was posted to Central Travancore in September 1959 where Messrs. A. V. Thomas & Co. Ltd. very kindly provided accommodation for him on Arnakal Estate. He continued to work there for the rest of the year.

The post of Agronomist which fell vacant consequent on the resignation of Mr. G. N. Joshi towards the end of March 1959 remained unfilled during the year under report.

Mr. D. Arunachalam, Clerk at Coonoor, resigned in June 1959 and Mr. S. Kailasanathan was appointed to the post as from July 1960.

Tea Experiment Station, Devarshola : Excepting usual upkeep, no additions or alterations were made to the Tea Experiment Station buildings during the year.

Climatic conditions were most unfavourable for the growth of tea. As indicated in last year's report, the prolonged and severe drought early in 1959 resulted in almost total absence of rush crops normally harvested in April—May. When the rains came, they were too heavy and continuous to permit harvesting of good crops in the succeeding months. The tea took a long time to recover from the ill-effects of drought and the year ended with a comparatively low crop.

13 acres of tea in bearing yielded 70,625 lbs. green leaf for the year as against 91,376 lbs. in the previous year, thus registering a drop of 20,751 lbs. Based on an average outturn of 23%, the quantity of green leaf harvested from 13 acres represents an average yield of 1,250 lbs. made tea per acre for the year as against 1,616 lbs. in 1958-59. By the sale of the year's crop at 25 nP. per pound of green leaf, a sum Rs. 17,656.25 was realised.

The monthly distribution of crop during the year was as follows:—

MONTHLY CROP STATEMENT

		Lbs./green leaf	Average for past 5 years Lbs./green leaf
April	1959	2,856	4,063
May	,,	2,589	6,991
June	,,	9,519	6,918
July	,,	7,203	8,257
August	,,	5,544	7,805
September	,,	10,040	8,536
October	,,	6,527	9,702
November	,,	10,742	7,676
December	,,	5,113	5,186
January	1960	4,952	4,007
February	,,	2,798	2,667
March	,,	2,742	2,548
		70,625	74,446

Correspondence: The correspondence at the Station registered a small drop over the previous year and the number of technical enquiries received was also smaller. These were more than offset by the increased volume of correspondence handled by the Chief Scientific Officer at Coonoor. Taking the two centres together, both the correspondence and the number of technical enquiries showed a substantial increase over last year.

Publications: A total of 12 scientific papers were prepared by the technical staff of the Department during the year under report. Some were published in scientific journals, some appear in the proceedings of the VII Annual Scientific Conference (Bulletin No. 19) while the rest comprising of five papers are included as an Appendix to this report. The titles of these articles are given in the reports of individual officers which follow.

Touring: The following tours were undertaken during the year by the Chief Scientific Officer:—

April	1959	—	Craigmore Estate, Nilgiris. Rousdonmullay Estate, Nilgiri-Wynaad.
May	,,	—	Anamallais, Central Travancore & Mundakayam.
June	,,	—	... ...
July	,,	—	Thiashola Estate, Nilgiris.
August	,,	—	Anamallais.
September	,,	—	Touramulla Estate, Wynaad.
			Sholur and Kodanad Estates, Nilgiris.
October	,,	—	Central Travancore.
November	,,	—	Tocklai, Assam.
December	,,	—	... ...
January	,,	—	Asojaya Estate, Nilgiris.
February	,,	—	... ...
March	,,	—	Anamallais and Central Travancore.

In addition, periodic visits were paid to the Tea Experiment Station, Devarshola.

The touring done by the other officers of the Department is detailed in their respective reports.

UPASI Exhibition : The Scientific Department participated in the 1959 UPASI Exhibition. The exhibits included specimens of tea pests and diseases of topical interest, pictorial representation of the effects of manuring and equipments of interest.

VII Annual Scientific Conference : The staff position having improved, it was decided to resume the usual Annual Conference which could not be held last year. The conference took place on 25th March 1960 and was attended, among others, by representatives of tea research organisations of North-East India, Ceylon and Pakistan.

Research Expansion Scheme : It has again to be reported that much progress could not be made in implementing the expansion scheme. Pending the finalisation of the sale deed in respect of the land, the Madras Government accorded permission for us to enter upon the land for starting preliminary work on building construction. Tenders were called in for the construction of the laboratory, but as the cost of even the lowest tender was far in excess of the sanctioned estimate, the matter had to be referred to Central Government. After protracted correspondence

and with various revisions in the tender, the Central Government finally approved of the tender and the recommended contractor. By that time the building season was very nearly over and beyond commencing the work of earth cutting and levelling, no further progress was possible before the rains set in.

In respect of the Central Travancore Station, the area was fenced in and a road traced. It is hoped that construction work planned for 1960—61 will be undertaken in time. The quantity estimates for the laboratory and staff quarters, the plans of which have been approved by the Tea Board, are being got ready for tender action.

Boards and Committees : The Chief Scientific Officer was the nominee of the UPASI on the following Boards and Committees :

1. Board of Agriculture and Animal Husbandry in India-Crops and Soils Wing.
2. The Nilgiri District Soil Conservation Board.
3. Fertilisers and Pest Control Products Sub-Committee and the Agriculture and Food Products Division Council of the Indian Standards Institution.
4. Tea Research Liaison Committee of the Tea Board.

Two meetings of the Nilgiri District Soil Conservation Board and two meetings of the Tea Research Liaison Committee held during the year were attended, but not any of the meetings convened by other organisations on which UPASI is represented.

Tea Board Research Liaison Committee : No new research schemes were formulated during the year, but the ones started in the previous years and referred to in last year's report continued to function. The schemes in respect of the proposed Fundamental Research Institute for Tea and a Research Station in the Dooars were finalised and, with the approval of the Board, have gone up to Government for necessary sanction.

Visitors : Representatives of commercial organisations, both Indian and overseas, visited Coonoor and Devarshola from time to time. In addition, we were pleased to welcome during the year the following visitors :

Mr. P. P. I. Vaidyanathan, I.C.S., Secretary to Government of Madras, Food and Agriculture, Mr. A. Y. Swamy, Director of Cinchona, Dr. I. S. Bhatia, Senior Biochemist, and Mr. P. M. Glover, Senior Advisory Officer, both of Tocklai Experiment Station, Assam, Dr. F. H. Abbasi, Chief Scientific Officer of the Pakistan Research Station and Officers of the Coffee Board Research Station and of the Central Food Technological Research Institute, Mysore.

The contacts and discussions which we had with the visitors have been of great value.

The Indian Standards Institution requested this year also for assistance for imparting in-field training to two of their Probationary Assistant Directors in all aspects of tea culture and manufacture. The request was complied with and the probationers spent one day in Coonoor and 3 days at Devarshola

PART II — RESEARCH AND ADVISORY

The year under report started with a somewhat difficult staff position. The Botanist and the Agronomist had left the service of the UPASI and the Scientific Department was also short of an Entomologist. The work of the Department including all the advisory work had to be shared by the Soil Chemist, the Plant Pathologist and myself. The position, however, improved later in the year with the appointment of an Entomologist and the re-engagement of the Botanist.

The screening of new fungicides against blister blight which has become a regular feature in the blister blight season every year was undertaken this year also. in addition, the Plant Pathologist was engaged in studies on other aspects of control such as extension of spraying intervals, retention of fungicides under different intensities of rainfall, etc. Root diseases and their control have also received his attention.

Work on vegetative propagation and weedkillers and growth studies which had been interrupted was resumed by the Botanist.

Soil and manure analyses and evaluation of fungicides and insecticides have become the full time work of the Soil Chemist who is also in charge of the routine work of the Station. These duties leave him very little time for research.

Manuring: The manurial experiments in progress have not given any more information than what has already been indicated in previous reports. Cessation of manuring over two pruning cycles has reduced the mean cycle yield by 29.1%. The absence of phosphoric acid in the fertiliser mixture has had no effect on yield over a period of 20 years.

In view of the Government's policy to restrict the supply of sulphate of ammonia and encourage the use of alternative nitrogenous fertilisers, arrangements have been made to lay down a field trial for testing the relative efficiencies of various forms of nitrogenous fertilisers.

Blister Blight: 15 different formulations of fungicides were subjected to field tests during the year. These included two antibiotics, two mixtures of antibiotic and basic copper, five organic fungicides and six straight copper fungicides. None of the new formulations tested could be rated as superior to a copper fungicide, but a formulation (Agrimycin 500) combining an antibiotic with copper has given satisfactory results even when the intervals between applications were extended to

14 days. The formulation requires to be tested further before being able to recommend it for estate practice in preference to straight copper fungicides. The full results of tests carried out are to be found in a separate paper included in the Appendix (pp. 36-48).

Work on resistance of copper fungicides to the washing action of rain was continued from which several interesting features have emerged. An observation of practical value is that, provided the spray has had a few minutes' time to dry on the leaf surface, subsequent washing by rain of moderate intensity will not appreciably reduce the biological effectiveness of the spray deposit. It was further observed that even spraying during rain will not be completely wasteful except under conditions of very heavy downpour. A paper on this subject was presented at the VII Annual Scientific Conference and appears in the Proceedings of that Conference (Bulletin No. 19, pp. 8-17).

Diplodia Disease: This disease caused by the fungus *Botryodiplodia theobromae* was the subject of an extended study by the Plant Pathologist. His observations based on the pathogenicity trials carried out go to show that the fungus is a primary pathogen which can infect and kill healthy tea plants even in the absence of any other predisposing factor and that the view currently held that this fungus is a 'secondary' invader needs to be revised. The full details of his investigations are published in Bulletin No. 19, pp. 18-28.

Root Diseases: In pot and field tests carried out with various soil fumigants in the control of the common root diseases of tea, "Vapam", a proprietary product based on sodium methyl dithiocarbamate, has shown great promise and further work with it is under way. This fumigant has also given indication of its usefulness in the control of eelworm. The details of a trial carried out in an area of mature tea infested with eelworm are given in the Plant Pathologist's report.

Vegetative Propagation: Systematic work in this line was resumed since the time the Botanist was reengaged. Bush selection and progeny tests are being carried out, in addition to studies on the effect of soil pH and of growth promoting substances on rooting. Current views on the effect of growth promoting substances are conflicting, but our work has indicated that quicker root formation and heavier root system would result from the treatment of cuttings with indole-butyric acid. A list of references on the subject with the Botanist's annotation is included in a paper appearing in the Appendix (pp. 49-58) which may be of interest to those engaged in vegetative propagation work.

In the course of advisory work, several cases of failure of V. P. cuttings were reported which on examination revealed stalk necrosis and the presence of *Colletotrichum camelliae* (Brown Blight fungus) and *Pestolotia theae* (Grey Blight fungus). In order to establish whether or not these fungi are primarily responsible for the stalk-rot, artificial inoculation tests were carried out which proved that they are capable of producing the stalk-rot. It was considered probable that the infection

originates from the shoot of the mother bush and control trials indicated that watering the callus beds immediately following the planting of cuttings would be of value. A short paper on the subject by the Plant Pathologist is included in the Appendix, pp. 59-62).

Polythene film was tested for various purposes in the course of nursery work and a short note by the Botanist is included in the Appendix (pp. 63-65.) indicating the different uses to which this material can be put in the vegetative propagation of tea.

Weedkillers : The field trial with Dowpon started in 1958 was continued during the year and the results obtained to date are discussed in a paper presented at the VII Annual Scientific Conference (Bulletin No. 19, pp. 49-55).

Mites : Reports of damage by mites continued to be received during the year and observations during visits to estates in the diffrrent districts have confirmed the seriousness of the problem. The predominant species infesting tea all over South India is Purple Mite *(Calacarus carinatus)*, although Red Spider (*Oligonychus coffeae*) and Scarlet Mite (*Brevipalpus australis*) occasionally cause serious damage, but their attacks are not so widespread. The severity of attack by Purple Mite is frequently so great, specially in the first and second year fields, that crop losses of the order of 50 lbs to 150 lbs. of tea per acre are not uncommon.

The overhead shade in tea, generally speaking, is much lighter than it used to be in the past and observations go to show that lack or inadequacy of shade is the biggest single factor contributing to the heavy build-up of mites. In areas where shade density is satisfactory, there is evidence to suggest that mite incidence is comparatively lower.

Drought is undoubtedly a factor conductive to mite damage, but a prolonged drought is not invariably associated with greater damage nor seasonal rains in the dry weather months necessarily limit the activities of the mite. The extent of temperature fluctuations in the dry weather months is often alleged to influence the build-up of mites, but this question requires to be more fully investigated before reaching any definite conclusion.

While suitable cultural practices have a definite place in the control of mites, it must be recognised that chemical control cannot altogether be dispensed with. The choice, however, of an acaricide is by no means simple as the one chosen must pass perhaps the most stringest tests. In addition to being efficient in killing the mites, it should leave no residue on tea which may contribute to a toxic hazard to the consumer ; it should impart no taint, however inocuous it may be, and it must be fairly safe in the hands of unskilled labour who carry out spraying and dusting. These considerations severely restrict the choice of a suitable acaricide and the few that do hold out promise are unfortunately still very expensive. Tests carried out during the year with various acaricides are mentioned in the Entomologist's report. The Entomologist has also started studies on the bionomics of the three mites, their

seasonal history and the prevalence of natural enemies. These may eventually provide some information which may lead to mitigation of damage by modification of cultural practices.

It is frequently mentioned that the mites are present in Grevilleas also and that any chemical control measure undertaken on tea would be valueless unless the infestation on Grevillea trees is also dealt with simultaneously. While this is true of Red Spider, and possibly also of Scarlet Mite, it does not certainly apply to attacks of Purple Mite. The last named mite has not so far been noted on Grevilleas and this shade tree cannot therefore be incriminated for attacks building up on tea.

Shot-hole borer : This pest has been the cause of some concern in Central Travancore as, associated with its damage, considerable die-back of branches and death of bushes following pruning have occurred on some estates. Investigation on the spot and subsequent isolation of fungi from the borer-infested branches carried out by the Plant Pathologist suggest that these fungi gain entry into the stem through the borer galleries and cause the die-back. The pathogencity of the fungal isolates is under study.

The problem of control of Shot-hole borer is indeed a difficult one, as the work done in the past and that is still being done now in Ceylon has not opened the way for devising a satisfactory control measure. Nevertheless, a study of the problem in the light of local conditions has recently been undertaken by the Entomologist and a field trial incorporating treatments with systemic insecticides and fungicides has also been started. The experiment has not run long enough to permit of any comments being made.

Acknowledgements : It is again a pleasure to acknowledge with gratitude the assistance which the Department received from all sections of the planting industry and commercial organisations connected with planting. The help and guidance received from the Tea Product Sub-Committee and the UPASI Secretariat have been most valuable and grateful acknowledgements are made to them.

Our relations with our sister organisations in Assam and Ceylon have continued to be cordial and we are grateful to them for all the cooperation and assistance we have received.

The Coffee Board Research Department and the Central Food Technological Research Institute are organisations with whose officers we have frequent contacts. For opportunities of discussion and for other forms of assistance, we are most grateful to them.

Before concluding, I wish to express my colleagues' and my gratitude to the managers of estates visited during the year for all the help and hospitality we have received.

S. Ananda Rau,
Chief Scientific Officer.

METEOROLOGICAL DATA

(1959—1960)

Months.	Rainfall in inches.	No. of days with rain.	Air.		Soil*		Humidity.		Vapour Pressure.		Cloud.	
			Average noon maximum	Average overnight minimum	8 30 A. M.	3 00 P. M.	8.30 A. M.	3.00 P. M.	8.30 A. M.	3.00 P. M.	8.30 A. M.	3.00 P. M.
April 1958	1.01	5	87.5	65.8	82.8	92.3	88.8	54.7	23.3	22.1	—	—
May ,,	4.49	16	83.4	66.7	80.6	88.3	89.9	74.4	24.4	24.4	0.9	1.3
June ,,	20.40	23	74.1	64.6	74.6	78 8	92.2	89.8	22.0	22.8	3.6	1.8
July ,,	29.89	30	70.9	64.2	72.0	75.1	92.5	91.8	20.4	21.5	7.0	6.7
August ,,	9 38	26	73.0	63.7	74.4	78.0	93.0	90.2	21.0	21.9	6.1	6.0
September ,,	10.12	24	75.8	64.0	75.8	79.8	94.3	85.7	21.8	23.7	2.4	1.7
Octobor ,,	6.75	17	77.7	63.6	76.2	80.1	95.0	86.1	22.0	24.7	1.2	1.8
November ,,	1.90	9	76.8	62.2	75.0	78.8	95.5	75.4	20.7	22.2	1 9	0.5
December ,,	0.96	2	75.7	59.9	71.4	74.9	89.9	60.0	17.9	17.4	—	—
January 1960	—	—	78.9	58.9	72.1	76 8	92.6	57.3	17.7	18.1	—	—
February ,,	—	—	83.3	59.0	73.6	79.6	78.5	36.6	15.9	13.8	—	—
March ,,	2.05	6	85.2	63.0	77.3	82.3	94.1	56.3	21.9	21.2	—	—
TOTAL	86.95	158										

*at 1 foot depth

REPORT OF THE SOIL CHEMIST

(1959 — 1960)

Advisory and Research :

In connection with advisory and research work the following samples were analysed during the year :

Soils	187
Manures and Manure Mixtures	48
Fungicides and Insecticides	7
Rubber Leaves ...	41
Made Tea	9
Tea Leaves	183
Lime	1
Total number of estimations	880

In addition to the analyses of the above samples, twentyfour general enquires received attention.

Soils :

Majority of the soil samples examined were from prospective nursery sites, while a few were from areas intended to be replanted. All these samples were tested for reaction and organic matter, Stress is laid once again on the necessity of having the soils tested for freedom from root-knot eelworm infestation, when choosing sites for nursery purposes. If the soil is infested with eelworm, examination of the roots of weeds growing in the area will show knots or galls on them, their number depending on the degree of infestation.

Some of the soils tested were found to be unsuitable because of unfavourable reaction. Application of sulphur will increase the acidity of the soil, the quantity to be applied depending on the original reaction of the soil and its buffering capacity. The economics of sulphur application depends on the area of the nursery and the area to be replanted. The amount of sulphur to be applied has to be determined by laboratory estimation for individual soils. Unfavourable soil reaction and hard sub-soil were found responsible for death of young tea plants in a small area in an estate visited. Some portions were interspersed with rocks at a shallow depth.

Soil samples were also received from patches wherein bushes were dead or dying. In these cases the soil was found to be suitable for tea and the death or weakened condition of the bushes was attributed to either drought or attack by disease.

Manures and Manure Mixtures :

While most of the samples sent for analysis conformed to the guaranteed analysis, in a few, discrepancies between laboratory and guaranteed figures arose. It is essential that the sampling of the mixtures to be sent for analysis should be carried out properly according to the details given in the Advisory Leaflet No. 2 of the Scientific Department.

Fungicides and Insecticides :

The suspension figures for a sample of copper fungicide and a sample of DDT wettable powder were not found satisfactory. The degree of protection given by such formulations will not be quite good. At the request of a plant protection firm, samples of tea were manufactured in a miniature roller and drier from tea bushes sprayed with an insecticide. These samples were intended for residue analysis. The analysis of rubber leaf samples sprayed with copper formulations for copper content was also undertaken for the same firm. The analysis of tea leaves for copper content was in connection with the investigation on the retention and efficiency of copper fungicide under the influence of simulated rainfall.

Blister Blight Trials :

Full details of the season's trials in the control of blister blight are given in the Appendix.

Publication :

A paper on "Retention and Efficacy of Copper Fungicides under the Influence of Simulated Rainfall" was read at the Seventh Annual Scientific Conference, 1960.

Visits :

Attended the UPASI Annual Meetings in August and the Annual Scientific Conference in March, in Coonoor.

Field Experiments :

27-Ptot (3 x 3 x 3) Factorial Experiment — Tea Experiment Station.

Yield records from eight plots, four to study the effect of cessation of manuring and four to study the effect of continued withholding of phosphoric acid were maintained.

TABLE I

Cessation of Manuring

Yield per plot in lb. green leaf

Cycle	Plot Nos. 8	17	18	27	Plot Mean
II	563	424	504	624	546
III	641	440	564	702	587
IV	874	554	698	997	774
V	652	352	574	692	555
VI	469	185	299	435	347

TABLE II

Effect of withholding Phosphoric acid

Yield per plot in lb. green leaf

Cycle	Plot Nos. 5	9	15	26	Plot Mean
II	369	477	390	373	403
III	400	470	442	385	425
IV	539	596	385	538	577
V	379	594	530	468	493
VI	316	615	494	431	464

The four plots which had not been manured from 1954 April onwards have declined in yield considerably. The bushes are due for pruning in April, 1960.

Withholding of phosphoric acid does not appear to have adversely affected the yield so far.

15-Plot (3×5) Randomised Block Experiment — Tea Experiment Station.

This tea was pruned in April 1959. The yield figures are given in Table III.

TABLE III

Yield in lb. green leaf

Nitrogen 60 lb./acre	Potash 60 lb./ acre	Nitrogen+Potash 60 lb.+30 lb./acre
821	612	876

The application of potash only has once again resulted in lesser yield than the other two treatments.

25-Plot (5×5) Randomised Block Experiment—High Range—Nullatanni Estate

TABLE IV

lb. made tea per acre

O	N	NP	NK	NPK	Difference required for sig.
872.1	1049.8	1058.9	995.8	1065.9	135.5 lb.

Except treatment NK, all other treatments have increased the yield significantly.

V. JAYARAMAN
Soil Chemist

REPORT OF THE BOTANIST

(1959—1960)

1. General:

Dr. K. S. Venkataramani rejoined the post of Botanist in December. This report covers a period of three and a half months from 17th December 1959 to 31st March 1960.

2. Advisory:

The work of the Division of Botany is mainly concerned with the botanical aspects of the tea bush and of such ancillary crops as shade and green manures. The technical letters written during the year comprised answers to enquiries on identification of plants, weed control and vegetative propagation of tea.

3. Tours:

The Botanist was deputed for an investigation of some citrus problems on an estate on the Anamallais in January 1960.

A visit was made to Coonoor in March 1960 in connection with the Seventh Annual Conference of the UPASI Tea Scientific Department.

4. Publications:

The following papers were written:

1. "Control of grass weeds in tea fields with dalapon" (Paper presented at the Seventh Annual Conference of the UPASI Tea Scientific Department.)
2. "The effect of growth substances on rooting of tea cuttings—A review" (see Appendix to this Annual Report).
3. "The use of polythene in vegetative propagation of tea" (see Appendix to this Annual Report).
4. "Common English and botanical names of some grasses" (awaiting publications.)

5. Research:

TEA (*Camellia sinensis*)

(i) *Growth study:*

Experiments to study the factors concerned in banji formation has been planned. It is premature to comment on them at this stage, but it is hoped that in another years' time sufficient data to warrant some conclusions may be available.

(ii) *Grass weed control in tea fields:*

(a) The field experiment started in the year 1958 was continued. The results obtained during the dry period November 1959 to March 1960 are summarised below;

Treatments.	Yield of green leaf in lb. from 4 plots of 35 bushes each
1. Untreated control	88
2. Dowpon: 3 applications each 5 lb./acre	102
3. Dowpon: 2 applications, 10 lb. & 5 lb./acre	89
Difference required for significance at P = 0.05	11.8

There was no evidence of any phytotoxic symptom on the tea bush in any of the treated plots. The yield was the greatest in the plots treated with three applications of Dowpon (dalapon) at 5 lb. per acre per application. There was some depression of yield in plots treated with 10 lb. of Dowpon per acre in a single application, but eventually those plots also improved in their yielding capacity and at the end of the period under observation, they yielded as much as the untreated controls. Full particulars of this trial are given in the paper presented at the Seventh Annual Conference of the UPASI Tea Scientific Department. Dalapon appears promising in the control of grass weeds in tea fields and large scale field trials are necessary to work out the economics of grass weed control with this chemical weedkiller.

(b) Laboratory trials have shown that *Mimosa invisa, Crotalaria grahamiana, Sesbania cinerescens, Indigofera teysmanii* and *Stylosanthes gracilis* are tolerant of Dowpon when applied to the soil at the rate of 5 lb. per acre. Field observations show that *Mimosa pudica, Crotalaria lanata, Desmodium triflorum, D.hirsutum* and *Centella asiatica* are also tolerant of Dowpon. Further studies on these lines are envisaged.

(iii) *Vegetative propagation:*

(a) **Selection of mother bushes:** Twenty bushes were marked out for testing their rooting capacity and rooting behaviour, yield performance and quality.

Twelve bushes which were flushing well during the dry weather, when the surrounding bushes showed drought effects, were marked as potential drought resistant bushes. Their rooting behaviour and the performance of the clonal progeny have yet to be determined.

On the basis of weekly pluckings during the dry weather, four bushes have been tentatively selected as potential high yielders, giving more than four times the field yield. Their yielding capacity is still being tested.

(b) **Progeny test:** Five clones have been planted in the field for a pilot progeny test. Only a few plants have been planted, as the object of this planting is only to study the following features: branching and spreading habit; rooting of cuttings from young plants; variations in morphological characters, if any; and flushing behaviour of the different clones.

(c) **Rooting capacity as influenced by the position of the leaf on the shoot:** A trial was undertaken with two good rooting clones to see whether rooting is influenced by the position of the leaf on the shoot. The bud and the first two tender leaves in a shoot were discarded and so were the leaves on red-wood at the lower part of the shoot. Greenwood 'leaf and internode' cuttings which could be taken from the middle part of the shoot were employed. The results are presented in the following table:

Position of leaf from apex of shoot	% rooting at the end of 12 weeks	
	"BBRB"	"DRB"
3rd leaf	92	88
4th ,,	96	80
5th ,,	100	84
6th ,,	96	88
7th ,,	96	88
8th ,,	92	84

All mature green-wood internode cuttings root equally well in these two clones and it would appear, therefore, that for experimental purposes a mixture of cuttings from different positions on the shoot will not materially affect the treatment effect.

(d) **pH of the rooting medium:** An earlier study indicated that sandy loams with pH values ranging from 4.46 to 5.39 are suitable for raising tea cuttings (UPASI Tea Scientific Department Bull. 18, 1958, pp. 52-56). A further trial was carried out with two kinds of soil and with cuttings from a single clone (BBRB). In both soils, a lower pH value of the rooting medium was more conducive to better rooting of the cuttings. One point of special interest that has emerged out of this trial, and which is well worth pursuing further, is that in an open soil, such as a sand-soil mixture (1 : 3) employed in the experiment, tea cuttings may tolerate a higher pH value (5.12) than in a soil with a lower amount of sand. In fact, the root system was much better in the sandy soil than in the other soil with a much lower pH value (4.39). Details of the experiment will be presented elsewhere.

(e) **Effect of growth substances on rooting of tea cuttings :** As has been recorded in earlier reports, indole-butyric acid (IBA) has consistently produced a heavier root system in the treated cuttings than in the untreated ones. The number, length and dry weight of roots were all more in the treated cuttings than in the controls. Our experience shows that more liftable rooted plants could be obtained in a shorter time when the cuttings are treated with IBA than when they are not. Further particulars of this aspect of work will be published shortly.

MISCELLANEOUS

(i) **Fruits :** The Botanist visited a citrus orchard in an estate in the Anamallais to investigate the problem of decline of mandarin oranges *(Citrus reticulata)*, and poor cropping in Sathgudi oranges (*Citrus sinensis)* and limes *(Citrus aurantifolia)*.

The seven year old mandarin trees had not made satisfactory growth and this was generally attributed to irregular and inadequate manuring. Most of the trees appeared unhealthy with a marked yellowing of the foliage and weak branches. Typical symptoms of zinc deficiency were also noticed on some of the trees. A mosaic pattern, unlike zinc deficiency symptoms, and veinal chlorosis were also displayed by many of the sickly looking trees. Veinal chlorosis, corking and splitting of the veins on the upper surface of the leaf, which neatly agree with the symptoms described in literature for Tristeza virus, were evident. These symptoms, which are not commonly associated with other diseases of disorders of citrus, lead one to suspect that Tristeza virus is the most probable cause of the decline of mandarin oranges in this orchard. It is realised, however, that confirmation of this could be obtained only through systematic transmission studies. Evidence of association of Tristeza virus with the decline of mandarins in other parts of the country lend support to our observations.

Fruit sucking bugs (*Vitellus orientalis*) were noticed in numbers on Sathgudi orange trees and they appeared to have caused severe damage to the fruits. Considerable shedding of fruit was also observed.

Leaf miner *(Phyllocnistis citrella)* attack was very severe in the lime plants. Almost every leaf on all newly formed shoots was infested and growth of shoots was retarded. The entire top portion of the plants appeared silvery and shining and the writer has never before seen such a severe infestation by leaf-miner. Tristeza was suspected on some of these plants also.

Pears (*Pyrus communis*) and plums (*Prunus domestica*) in the orchard have made excellent vegetative growth, but the flowering and fruit set were reported to have been poor. These deciduous fruit trees make their best growth only at elevations higher than 4500 ft. above the mean sea level, and it is very unlikely that they will attain any commercial importance in the Anamallais, especially in orchards situated below 4000 ft.

(ii) **Effect of growth regulators on germination of some leguminous seeds :** A series of trials have been planned to ascertain the effect of different growth regulators on the germination of seeds and seedling vigour in a few leguminous green manure crops. Gibberellic acid appears to break the dormancy in some old seed of *Crotalaria grahamiana* and *Priotropis cytisoides* in that the percentage of germination was greater in the treated than in the untreated seed. There was no effect, however, on fresh viable seed. The experiments have not yet been completed and the results will be made available at a later stage.

ACKNOWLEDGEMENT

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K. S. VENKATARAMANI,
Botanist.

REPORT OF THE PLANT PATHOLOGIST

(1959—1960)

General :

During the year sixty-six plant specimens were recived for examination and report on these, identifying the disease and suggesting appropriate control measures, were sent out. The total number of correspondence handled in the plant protection work exceeded 150. The majority of enquiries related to diseases of the tea plant, while some on shade plants, coffee and cardamom were also received.

Touring :

The following visits were made during the year :

April	1959	— Terrace Estate, Nilgiris
May		— Pasumullay, Munjamullay, Nellikai, Wallardie, Arnakal, and Kadamankulam Group, Central Travancore.
		— Rousdon Mullai Estate, Nilgiri-Wynaad.
June		— Rousdon Mullai Estate, Nilgiri-Wynaad.
August		— Farm Tea Estate, Nilgiris.
		Rousdon Mullai Estate, Nilgiri-Wynaad.
September		— Devon Estate, Nilgiri-Wynaad.
		Sussex Estate, Nilgiri-Wynaad.
October		— Devon Estate and Daverashola Estate, Nilgiri-Wynaad.
November		— Kalajothi-Rajalakshmi Estate, Nilgiri-Wyaand.
December		— Daverashola, Devon, Rousdon Mullai Estates, Nilgiri-Wynaad.
		Arnakal Pasumullay and Semni Valley Estates, Central Travancore.

In addition to the above estate visits, I participated in the UPASI exhibition at Coonoor in August 1959 and in the Seventh Annual Conference of the Scientific Department held at Coonoor in March 1960. I also attended the Forty-seventh Annual Session of the Indian Science Congress at Bombay in January 1960, as a delegate of the UPASI Scientific Department. At this session of the Science Congress I participated in a symposium on " Dynamics of Soil Fungi " and read a

paper on " Factors affecting the spread of root infection fungi ". This paper has been accepted for publication in the Memoirs of the Indian Botanical Society.

Publications :

The following articles were communicated during the year to the journals noted against each of them :

1. Control of Blister Blight of Tea in Southern India- The 1958 Field Trials. *Ann. Rep. UPASI Sci. Dep. Tea Sect. for 1958-1959,* pp. 28-35 (jointly with the Soil Chemist).

2. The Relation of interval between fungicide application to the control of blister blight disease of tea plants. *Ann. Rep. UPASI Sci. Dep. Tea. Sect. for 1958-1959,* pp. 36-41 (jointly with the Soil Chemist).

3. The Relation of interval between fungicide spraying on tea leaves and subsequent washing by simulated rain to blister blight infection. *Ann. Rep. UPASI Sci. Dep. Tea. Sect. for 1958-1959,* pp. 42-45.

4. Factors affecting the spread of root infecting fungi. *Mem. Indian Bot. Soc.* 1960 (in press)

5. Foliar application of nutrients and rhizosphere microflora of *Camellia sinensis. Nature* (in press).

ADVISORY

Root Diseases : Excepting for isolated reports, very few inquiries were received on root diseases caused by *Fomes noxius, Poria hypolateritia, Rosellinia arcuata and Ustulina zonata.* It seems likely that the incidence of these diseases is far more widespread and serious than the picture given by the number of specimens sent to the Experiment Station for identification and report. In the experience of the Plant Pathologist such diseases have been commonly observed in estates which were visited.

Root diseases caused by *Rosellinia arcuata and Botryodiplodia theobromae* were recorded on young V. P. plants and the damage done in one case was reported to be considerable. The symptoms of infection on young V. P. plants are not as readily discernible as on mature tea and sometimes it may be necessary to resort to microscopic examination to identify the causal fungus. In V. P. plants infected with *Rosellinia arcuata,* received for examination, the star-shaped patches were not readily noticed which in mature tea, attacked by this fungus, are invariably present under the bark. The fungal mycelium, however, was seen making profuse growth on the roots of the V. P. plants. In several of the attacked plants the collar was injured, the stem tissue being ringed over the collar region.

An instance of failure of young V. P. plants put out in the field due to an attack by *Botryodiplodia theobromae* came to light during the year. The disease was noticed in young supplies in one particular field. No ill-effects of drought were experienced in the area in question. Examination of the dead and dying plants revealed a severe infection of the roots by *Botryodiplodia theobromae* and the fungus was isolated from the affected plants in pure culture. The fungal pycnidia (fructifications) were observed embedded in the bark but were devoid of the white fringe which is commonly noticed encircling the pycnidia in the case of the diseased roots of mature plants.

Stem diseases : A report of stump rot caused by *Hypoxylon vestitum* Petch was received from an estate in the Nilgiris. This is not a disease common in tea estates in Southern India and is reported only occasionally. Instances of severe attack by red rust caused by the parasitic alga, *Cephaleuros parasiticus*, were recorded in tea estates in South and Central Travancore. During a tour of certain estates in Central Travancore it occured to the author that red rust was one of the serious problems in that area.

'Branch canker' caused by *Macrophoma theicola* was commonly reported from several estates in the Nilgiris, occuring in first year tea fields. In one instance, this disease was recorded in young tea. 'Die-back' due to *Leptothyrium theae* was also recorded in one estate in the Nilgiris causing widespread damage in 1st and 2nd year fields. It has been previously pointed out that in areas with past record of these two stem diseases, three prophylactic rounds of spraying with copper fungicides at fortnightly intervals be given soon after pruning. It was also indicative that in estates having past history of *Macrophoma theicola* and *Leptothyrium theae* diseases, pruning in the wet weather led to serious damage by the two organisms.

Leaf Diseases : Damage due to disease of 'brown blight' caused by *Colletotrichum camelliae*, 'grey blight' caused by *Pestalotia theae*, 'black rot' caused by *Corticium invisum* was frequently reported from several estates. In addition to these, one instance of damage caused by *Cercosporella* leaf disease was also recorded. Sooty mould on tea leaves (*Asterina camelliae*) was reported from two estates but caused little damage.

Prophylactic Spraying : It is a well known fact that prevention of fungal infection is a much easier proposition in plant protection than eradication of the established pathogen. Most of the commercial fungicides are effective only as protectants and, therefore, the timing of their application has to be appropriate for achieving satifactory results.

Prophylactic spraying against 'die-back' caused by *Leptothyrium theae*, *Macrophoma* 'branch canker' and the 'red rust' disease have been advocated in areas with either known past history of these diseases or wherein the diseases are occurring.

Estates with problems of die-back and/or 'branch canker' are recommended spraying with copper fungicides soon after pruning. Either 4-4-40 Bordeaux or any proprietary copper fungicide (containing 50% metallic copper) at the rate of 12 ozs. in 10 gallons of water may be employed. Approximately 50—60 gallons of the spray fluid are to be applied to one acre of pruned tea using a coarse nozzle, and the pruned branches given a good drenching. *Leptothyrium theae* enters the cut end of the pruned bush and causes die-back of the shoots developing from the affected branches, whereas *Macrophoma theicola* attacks young branches and branches which are either injured or affected by sun-scorch when exposed after pruning. A protective fungicide spray soon after pruning will be extremely useful in checking the spread of these diseases. Three applications with the fungicide at 14-day intervals should be given.

In the case of the 'red rust' disease, the casual parasitic alga, *Cephaleuros parasiticus*, produces sporangia on the stem of affected tea plants during April – May. Spraying copper fungicide in the affected areas in May, 2 – 3 applications at 14-day intervals, will inhibit germination of the algal spores and reduce fresh infection. The strength of the fungicide suspension as well as manner of spraying are the same as in the recommended prophylactic sprays against 'die-back' and 'branch canker'.

Diseases in the V. P. Nursery: Several instances were reported during the year of failure of V. P. cuttings in the nursery beds. Examination of the affected V. P. specimens revealed, in most cases, stalk necrosis which had extended to the entire length of the internode in some specimens. In some of the cuttings, part of the leaf and the petiole were also necrosed. Necrosis had invariably occurred before the cuttings had callused. In another type of failure of V. P. cuttings, the latter had formed a good callus but the root initials had rotted and the rotting had extended to the callus. On culturing the affected plant tissue, the following fungal organisms were isolated. *Colletotrichum camelliae* and *Pestalotia theae* from specimens in which stalk rot had set in prior to callus formation, and *Pythium* sp., *Cylindrocladium* sp. and *Fusarium* sp. from rotted callus tissue. When healthy V.P. cuttings were artificially inoculated with *Colletotrichum camelliae* and *Pestalotia theae*, stalk rot was produced, resulting in the failure of the cuttings. Results of the inoculation tests and the rooting response of V. P. cuttings to certain fungicides incorporated in the soil are given in the Appendix.

The occurrence of stalk rot in the V. P. nursery is attributable to the following factors: (1) an incipient stalk infection by either *C. camelliae* (the 'brown blight' organism) or *Pestalotia theae* (casual fungus of the 'grey blight' disease) on the mother bush; when cuttings from the infected material are planted the fungus could develop, causing the stalk to rot. (ii) spores of these two fungal organisms lodging on the stalk of V. P. cuttings after planting them in beds. Once a cutting is infected, it seems very probable that the infection spreads to others in the bed.

Root rot caused by *Pythium, Cylindrocladium* and *Fusarium* seems to be favoured by excessive watering of the nursery beds. These soil fungi are known to cause root rot and damping-off of seedlings in several plants but mainly under certain soil condition, viz., high soil moisture content.

SHADE PLANTS :

Die-back in Grevillea robusta : A serious outbreak of a disease in *Grevillea* plants was reported from several estates in the Nilgiri-Wynaad. An examination of the affected plants indicated that the terminal shoot and the branches had died back. In all such infected shoots and branches, fungal fructifications were observed at the focus of infection. The fungus has been identified as a species of *Dothiorella* and is probably a new species, in view of its parasitism on *Grevillea robusta.* Lesions similar to those found in natural infection were produced by artifical inoculations of *Grevillea* plants with the fungus. Whether the fungus can attack the uninjured plant stem or it gains entry only through a wound is being studied in trials under way. It is recommended that, wherever possible, the dead stem in the affected plants be cut back to healthy wood and the exposed end painted with a fungicide paste.

Albizzia moluccana : Deaths due to the Diplodia fungus, *Botryodiplodia theobromae,* attacking the root system of healthy *Albizzia* plants, was reported from an estate. On tea plants, this fungus is now being considered as a strong pathogen and attempts are being made to test possible control measures against the disease.

Stem disease in *Albizzia moluccana* and *Acacia decurrens* plants, caused by a species of *Phoma,* was recorded from an estate in Kerala and in the Nilgiris, respectively. Although this fungus is perhaps capable of infecting uninjured plant stem under favourable micro climate, it is regarded that any wound on the stem predisposes the plant to attack by *Phoma* as well as to several other fungal pathogens. As mentioned in our last annual report, the practice of tying shade plants to a stake is often responsible for wounds occurring on the stem through which fungal pathogens readily gain entry ; the string employed for tying the plants cuts into the plant stem during continuous rubbing when the plant is swayed by wind. A pad of moss, or any other material which will act as a cushion, placed between the plant and the string will prevent such damage.

RESEARCH

Blister Blight Trials: Blister blight disease of tea leaves, caused by the fungus *Exobasidium vexans,* was very severe throughout the South-West as well as the North-East monsoon periods. Testing of various fungicides was carried out in six field trials during the year, three in the South-West monsoon and three in the North-East monsoon period. Several new organic fungicide formulations, antibiotics and copper plus antibiotic mixture, namely, Actidione S, Actispray, Agrimycin 500,

Cyprex, Glyoxide, Orthocide 83 and Phaltan were tested out and some of these were found to give satisfactory protection against blister blight. Results of these trials are given in Appendix.

Field trials were again undertaken to test the effect of increased interval between application of Perenox and Blitox '50' on blister blight control, and it was observed that the former fungicide gave satisfactory protection against the disease even on 14-day rounds of spraying, thus confirming our earlier findings (for details see UPASI Scientific Department Annual Report for 1958-59, pages 36 - 41.)

Summary of 1958 and 1959 blister blight trials: The results of the field trials for the control of blister blight in 1958 and 1959 have appeared in the "Results of the 1959 Fungicide and Nematocide Tests" published by the American Phytopathological Society.

Resistance of copper fungicides to washing by simulated rainfall: Retention of copper in fungicides, sprayed on tea leaves and immediately followed by wash with different intensities of simulated rainfall, was studied as a possible guide to their effectiveness against blister blight disease in areas of heavy rainfall. Field tests were carried out with four formulations, each subjected to wash by simulated rainfall, for quantitative estimation of copper residue on the leaves after the wash, determining the pattern of copper distribution by taking rubeanic acid prints and evaluating the biological effectiveness of the copper residue by spore germination tests. These experiments were carried out in collaboration with the Soil Chemist and the results are given in a paper presented by him on "Retention and efficacy of copper fungicides sprayed on tea leaves under the influence of simulated rainfall" appearing in the Proceedings of the Seventh Annual Conference of the UPASI Scientific Department, 1960.

Diplodia Root Disease: During the last two years several instances came to light when serious damage caused by *Botryodiplodia theobromae* (commonly known as the Diplodia root disease) was reported. Plants killed comprised all categories, i.e., young seedlings in the nursery, supplies of basket as well as stump plants in the field, V. P. plants in the field and mature tea bushes after pruning. These observations taken in conjunction with records made by several investigators suggested a role to the fungus *Botryodiplodia theobromae* other than that of a secondary 'invader' assigned to it in the recent years. Indeed, it was deemed worthwhile to initiate a number of experiments which would throw light on this rather vexing problem, certain facets of which have never been understood clearly. Preliminary pathogenicity trials were undertaken with potted tea plants (3 year old stumps) which were artificially inoculated with *B. theobromae*. Some of the inoculated plants died, whereas those which did not succumb to the infection were lean and sickly. The root system of the infected plants on examination revealed that most of the feeding roots had rotted and the fungal fructifications were invariably observed on the tap

root. In subsequent trials these results were confirmed. It was also possible to induce disease reaction in young potted tea seedlings by inoculation with *B. theobromae*. Details of the investigation have been presented in a paper entitled "A reassessment of the Diplodia Root Disease of tea plants" read at the Seventh Annual Conference of the UPASI Scientific Department, 1960.

Eradication of Root Disease: Further to the pot and field trials on the survival of the tea root disease fungi, namely, *Fomes noxius*, *Rosellinia arcuata* and *Ustulina zonata*, in soil treated to various chemical fumigants, a small plot trial was carried out in a neighbouring estate for the control of the 'brown root disease' caused by *Fomes noxius*. A patch of tea infected by the disease was isolated by a trench 4' deep and 1' wide. In this patch, over a period of a few years, twelve tea bushes, one dadap and one *Grevillea* tree had been killed and removed, and at the time when the trial was laid one tea bush was dying. The spread of the fungal mycelium was traced on the lateral roots of this dying tea plant and was found to infect healthy roots of a neighbouring tea bush, which I shall refer to as 'sick' bush. The infection had advanced to about 2' of the bole along the lateral roots of the 'sick' plant.

The 'sick' plant and adjoining it three other healthy bushes were treated with Vapam (32.7% sodium methyl dithiocarbamate as active ingredient) as follows: In the area covered by the four treated plants, 18" deep holes were made in the soil, nine each in three rows and twenty-seven holes in all, and into each of these 10 ml. Vapam was poured and the holes plugged with earth. In addition to this, twelve 6" deep holes were made surrounding the 'sick' plant and into each of them 5 ml. of Vapam was poured and the holes plugged. Soon after the incorporation of the soil fumigant, the treated area was watered heavily. The trials was laid on October 6, 1959 and periodical observations were made till April 6, 1960. In January 1960, three months after the treatment, one tea bush had died of the 'brown root disease' in the untreated area but till April none of the Vapam treated bushes showed any symptoms of disease. The 'sick' bush was also flushing vigorously and in spite of drought had shown no indications of the disease. No phytotoxic symptoms were noticed in any of the treated bushes and although further trials are under way, plant safety to Vapam is reasonably assured.

The trials against the 'brown root disease' described here is only a preliminary investigation. The author is only too alive to its shortcomings in providing conclusive results, but the indication of success with Vapam in controlling this and other root diseases in tea is, nevertheless, there. More trials will have to be carried out with larger replicates and these will be taken up in the coming year.

Eelworm in mature tea: The Plant Pathologist collaborated with the Chief Scientific Officer and the Soil Chemist in an investigation into the effect of certain chemical fumigants on eelworm affecting mature tea (Tea Research Institute, Ceylon, consider mature tea to be susceptible only to *Meloidogyne brevicauda* but the species

in the present investigation has not been identified and, therefore, will be referred to as *Meloidogyne* sp). Damage to mature tea by eelworm has been recorded only from one estate in the Nilgiri-Wynaad and is not an extensive problem. But in the area where the eelworm is affecting tea bushes it seems to present a major problem. Affected bushes are on gradual decline and the root system of such bushes are gnarled and almost completely devoid of feeding roots. rendering them vulnerable to drought.

In a laboratory experiment soil from the top 6" was obtained from this eelworm infested area and potted in large 13" × 11" earthenware pots. The soil was kept moist for 2 weeks after which it was treated with various chemicals. Five replicates were run for each of the following treatments: (1) Vapam, one quart in 30 gallons of water per 100 sq. feet as drench, (2) Vapam, 30 gallons per acre as soil injection, (3) Nemagon, 15 gallons per acre as injection, (4) Nemagon, 30 gallons per acre as injection, (5) Basudin, 1 lb. in 20 gallons of water and 1 gallon of this mixture to 600 sq. feet as drench, (6) Untreated eelworm infested soil and (7) Untreated uninfested soil. Six weeks after the treatment 3-4 year old stumps were planted, three each in a pot. The experiment was run under thatch shade and at four months after planting, the stumps in one pot in each treatment were removed for observation No eelworm galls were, however, observed in the lateral root in any of the stumps, including those from the untreated eelworm infested soil, At this time germinated tea seeds were planted, three each to a pot, in the remaining four replicates of all the treatments. Three months after planting the seeds, the seedlings and stumps were again removed from one pot in each treatment but no eelworm infestation was observed on the roots of either the seedling or the stump in any of the treatments.

The results of the final observation made ten months after planting the stumps and six after planting the seedlings are given in Table I. Typical galls were noticed on roots growing in the unreated eelworm-infested soil and in one of the treatments but not in the others. Vapam, either as a drench or soil injection and Nemagon as soil injection were effective in controlling eelworm infestation, whereas Basudin as drench was ineffective. Results presented in Table I also indicate that good development of lateral roots occured in soil treated to Vapam. Nemagon at 30 gallons to an acre seemed to retard root growth.

One of the interesting observations made in this experiment was that the eelworm infestation on plants was not manifested till over 4—6 months after planting. Apparently this eelworm is markedly different in its mode of attack from the common root-knot eelworm, *Meloidogyne javanica*, which affects tea seedlings in the nursery.

Table I. *Root infestation in stumps, ten months after planting, and in 6 month old seedlings, by eelworm affecting mature tea as influenced by soil treatments (Scores for infestation: 0=No infestation; 1=1—5 galls; 2=6—10 galls, and 3=over 10 galls, per plant)*

Treatment	Replicate	Seedling infestation in plants			Stump infestation in plants			Dry wt. in g. of lateral roots in stump plants (Total of three)
		1	2	3	1	2	3	
1. Vapam drench	1	0	0	0	0	0	0	4.63
	2	0	0	0	0	0	0	7.56
	3	0	0	0	0	0	0	7.52
2. Vapam soil injection	1	0	0	0	0	0	0	10.72
	2	0	0	0	0	0	0	5.05
	3	0	0	0	0	0	0	7.69
3. Nemagon 15 galls. per acre	1	0	0	0	0	0	0	6.05
	2	0	0	—	0	0	0	7.05
	3	0	0	0	0	0	0	2.44
4. Nemagon 30 galls. per acre	1	0	0	0	0	0	0	4 21
	2	0	0	0	0	0	0	3.00
	3	0	0	0	0	0	0	3.39
5. Basudin drench	1	0	1	1	1	2	0	3.47
	2	1	1	—	2	1	1	2.09
	3	2	1	—	3	1	2	6.86
6. Untreated infested soil	1	0	1	—	3	3	3	7.10
	2	1	2	2	2	2	3	2.46
	3	2	2	3	3	2	3	4.80
7. Untreated uninfested soil	1	0	0	0	0	0	0	9.29
	2	0	0	0	0	0	0	8.27
	3	0	0	0	0	0	0	4.70

Wood-Rot and Shot-hole borer attack: The Chief Scientific Officer in his address at the Seventh Annual Conference of the UPASI Scientific Department mentioned about the tremendous build-up of shot-hole borer population in certain estates in Central Travancore. Although this pest has been recorded in this area for a number of years, it seems to have become a serious problem in the last 1—2 years. During a visit to one such affected estate it was observed that in a 24-acre pruned field more than 2000 bushes had failed to recover and in another field which had been skiffed, about 5—10 per cent. of the bushes were still bare, three months after skiffing.

Attempts were made to correlate the starch reserves in the roots with failure of shot-hole borer attacked bushes to recover from pruning. Fifteen bushes, each in the three categories of healthy, weak and unthrifty and dead tea plants, were selected at random and examined for starch content in the roots. Results in Table II showed that the pattern of starch content in those three categories was very similar and could not be correlated with the 'well being' of the bush. Shot-hole borer galleries were observed in both healthy and dead bushes but were significantly smaller in number in the healthy than in dead branches. Examination of the dead branches revealed discolouration of the tissue and the diseased tissue invariably yielded a species of *Fusarium, Nectria,* and a dark mycelial fungus in agar culture.

Table II. *Starch reserves in roots of tea bushes affected by shot-hole borer, six months from pruning*

Bush Nos.	Percentage starch content *		
	Healthy plant	Weak and unthrifty plant	Dead or dying plant
1	0	0	5–10
2	0	0	0
3	10–15	5–10	0
4	0	0	10–15
5	50–75	10–15	0
6	10–15	0	0
7	0	10–15	5–10
8	0	0	10–15
9	0	0	0
10	0	0	0
11	0	0	0
12	20–25	0	50–75
13	5–10	25–30	10–15
14	5–10	0	0
15	0	10–15	0

* Visual examination of colour developed on dipping the cut end of a root in iodine solution.

During another survey of shot-hole borer infested fields in an estate in Central Travancore in December 1959, twentyfive random bushes were selected in a heavily infested field. From these, two branches with galleries were cut and from each branch five pieces of tissue were taken and cultured on nutrient agar in Petri dishes. The fungi growing out of the tissue were recorded and the results are given in Table III.

Table III. *Total number of pieces of stem tissue yielding different fungi, out of five, from a single branch infested with shot-hole borer.*

No. of bush	Branch No.	*Pestalotia* sp.	*Fusarium* and/ or *Nectria*	*Botryo-diplodia theobromae*	*Rhizoctonia bataticola*
1	1	5	—	1	1
	2	4	—	3	—
2	1	4	1	1	1
	2	3	2	1	1
3	1	3	—	2	—
	2	2	3	1	—
4	1	5	3	2	—
	2	4	4	1	—
5	1	2	3	—	—
	2	3	—	—	—
6	1	1	1	5	—
	2	2	—	5	—
7	1	2	4	—	1
	2	4	4	1	—
8	1	2	—	1	—
	2	2	2	—	1
9	1	—	—	—	—
	2	—	—	—	—
10	1	5	—	—	—
	2	5	—	—	—
11	1	4	4	—	—
	2	3	5	—	—
12	1	4	—	3	1
	2	5	—	5	—
13	1	5	2	1	—
	2	3	1	2	—
14	1	5	2	1	—
	2	5	2	—	—
15	1	5	1	—	1
	2	5	—	1	—
16	1	—	5	1	—
	2	2	3	1	—
17	1	—	3	—	1
	2	2	3	1	—
18	1	2	4	2	—

	2	3	3	2	—
19	1	3	4	1	—
	2	3	3	—	—
20	1	5	5	—	—
	2	4	3	—	—
21	1	3	1	2	—
	2	3	5	2	—
22	1	5	—	—	—
	2	5	2	—	1
23	1	2	1	2	—
	2	4	4	2	—
24	1	1	2	2	1
	2	2	2	1	—
25	1	—	3	—	—
	2	2	1	2	—

It is seen that *Fusarium* and/or *Nectria* and *Botryodiplodia theobromae* were pathogens very frequently isolated from the shot-hole borer infested branch, while *Rhizoctonia bataticola* was found to occur in a few of the affected branches. It seems indicative that these fungi gain entry into the stem through the borer galleries and cause die-back under certain conditions. Experiments are under way to determine the pathogenicity of these fungal isolates and the environmental conditions under which they are liable to cause 'die-back' in affected tea stem.

Systematic Mycology : The following fungi were isolated during the year, all from the rhizosphere of tea plants.

1. *Chaetomium cochlioides* Palliser
2. *Chaetomium globosum* Kunze
3. *Gliomastix convoluta* (this isolate is regarded as a new variety of this species).
4. *Myrothecium* sp. (this is regarded as a new species).
5. *Nectria inventa* Pethybr. (syn. *Verticillium lateritium* (Ehrenb.)Rabenh)
6. *Paecilomyces marquandii* (Massee) Hughes.
7. *Scopulariopsis brevicaulis* Bain.
8. *Syncephalastrum racemosum* Schroeter.
9. *Mucor fragilis* Bain.
10. *Stysanus* sp. (this species has not so far produced synnemata).

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I am thankful to the Commonwealth Mycological Institute, Kew, for the identification of fungal cultures, to the Chief Scientific Officer and the Soil Chemist for their interest in some of the investigations and to the managements of several estates which I visited in 1959-1960 for their help and hospitality. It is also a pleasure to acknowledge the help received from various firms which have very generously sent us samples of their products for tests.

C. S. Venkata Ram,
Plant Pathologist.

REPORT OF THE ENTOMOLOGIST

(1959—1960)

I joined service in the middle of June 1959. During the first three months I was stationed at Tea Experiment Station, Devarshola, and greater part of the time was spent in getting familiar with all aspects of tea culture. Through the courtesy of Messrs A. V. Thomas & Co. Ltd., accommodation and facilities for work were provided by Arnakal Estate, Vandiperiyar, Central Travancore, where I am stationed since last September.

Touring: Ten estates in Central Travancore and one estate in Nilgiri-Wynaad were visited during the year. Two visits were made to Coonoor, one in August 1959 for the UPASI Exhibition and the other in March 1960 for attending the Seventh Annual Scientific Conference.

Publication: "Observation on Red Spider of Tea in South India" formed the subject of a paper contributed to Seventh Annual Scientific Conference held in March 1960.

Mites:

Damage to tea by mites was very prominent during the dry weather months of the year. Observation made during the year indicated that the severity of attack by mites has reached alarming proportions throughout the tea districts of South India. Considerable time was devoted to the study of the biology and bionomics of the three mites (Red Spider, *Oligonychus coffeae* Nietn, Scarlet Mite, *Brevipalpus australis* Tucker & Purple Mite, *Calacarus carinatus*, Green.) It has also been noted that Grevillea, Dadap and a few weeds are alternate hosts of Red Spider and Grevillea and Albizzia of Scarlet Mite. This discovery complicates the problem of control as any measure adopted in tea would not be fully effective unless attempts are made to control the infestation on the shade trees also at the same time.

Red Spider: The occurrence of Red Spider in Central Travancore was particularly widespread during the year. Work done on this mite formed the subject of the paper presented at the Seventh Annual Scientific Conference.

Purple Mite: This mite was also wide-spread during the year and caused great damage to tea in its first and second year from pruning. The necessity for treating large areas of tea is greater in the case of this mite.

Scarlet Mite: The population of this mite appears to be steadily increasing. It is the most dangerous of the three mites as it can cause almost complete defoliation of the infested bushes. It starts feeding near the leaf petiole and if the attack is serious, the leaf drops resulting in serious defoliation of the infested bush. In badly attacked areas in some of the estates in Central Travancore, the bushes presented a very thin appearance. Details of the life history of this mite are being studied.

Field Trials : Field trials were carried out against mites on a large scale with some of the acaricides and organo-phosphorous and systemic insecticides supplied by various firms for trial purposes. Some of the chemicals included in the trial are:—

Sprays :

1. Akar 338 EC (Tata-Fison)
2. Aramite WP (Bombay Chemicals)
3. Chlorocide WP (Boots Pure Drug)
4. Chlorocide Malathion (Boots Pure Drug)
5. Malathion (Lederle Laboratories)
6. Rogor (Tata-Fison)
7. Metasystox (M/s. Chika Private Ltd)

Dusts:

1. Akar 2% dust (Tata-Fison)
2. Chlorocide 2% dust (Boots Pure Drug)

Akar 338 has proved quite superior in controlling mites, while Chlorocide Malathion, Malathion and Aramite have also produced satisfactory kill of the mites. Chlorocide WP did not give any satisfactory control. Among the systemic insecticides, both Metasystox and Rogor have proved very effective.

Of the dust formulations tried, Chlorocide dust did not give satisfactory control, but 2% Akar dust was quite effective. Two rounds of dusting were carried out using 25 lb. of dust per acre per round.

Shot-hole borer :

Damage by this borer was observed on several estates in the Vandiperiyar area. The pest was observed to cause considerable die-back and death of bushes following pruning. Considering its potentialities for damage and the serious nature of attack in Ceylon, active work on this pest has been resumed. The Plant Pathologist's work has suggested that the galleries bored by the insect are subsequently invaded by fungi which cause the die-back of branches. A field trial incorporating treatment with systemic insecticides and fungicides has recently been laid out and the data are being collected.

Thrips :

Thrips continued to cause some concern during the year, especially in Central Travancore where rapid build-up of this pest has been observed to cause considerable damage to tea recovering from pruning. From present indication, Thrips have to be reckoned as a potentially serious pest. The study of its life history is being taken on hand and proper control measures are receiving attention.

A preliminary trial was made on a small scale with DDT and Dieldrin. Both have given satisfactory results though Dieldrin has given a better kill.

Flushworm:

Attack of flushworm was found throughout the year in tipping fields on many estates in Central Travancore, but there was no instance of serious damage. It is hoped to pursue investigation on all aspects of this pest.

Helopeltis :

Damage by this pest was not at all serious. The insect was found in small numbers and its damage could hardly be regarded as causing loss of crop. It is probable that this is largely due to greater attention given to the proper application of chemicals for control.

Minor Pests :

The following are the minor or occasional pests noted during the year:—

On Tea.

1. Red Slug (*Heterusia virescens,* Butl.)
2. Aphis (*Toxoptera aurantii,* Boyer)
3. Eelworm *(Meloidogyne* sp.*)*
4. Tea Tortrix (*Homona coffearia,* Nietn)
5. Tea Leaf Roller (*Gracilaria theivora,* Wlsm.)
6. Tea Leaf Miner (*Melanagromyza* sp.)
7. Neetle grubs

On Dadaps

1. *Myllocerus viridanus,* F. (weevil)
2. *Sthenias grisator,* Fb (ringer)

On Coffee

1. *Saissetia coffeae,* Walker (Brown bug)
2. *Coccus viridis* (Green bug)

On Cardamom

1. *Taeniothrips cardamomi,* R. (Thrips)
2. *Eupterote* sp. (Hairy Caterpillar)

Acknowledgements :

It is a pleasure to record here my grateful appreciation of the assistance received from Mr. P. W. Davidar, Manager, Arnakal Estate, during the period of my stay on Arnakal Estate. Grateful acknowledgement is also made of the hospitality received from the Managers of estates visited during the year.

N. R. Ananthakrishnan,
Entomologist.

APPENDIX

THE RELATIONSHIP OF INTERVAL AND RATE OF APPLICATION OF ANTIBIOTICS, COPPER AND ORGANIC FUNGICIDES TO THE INFECTION OF TEA PLANTS BY *EXOBASIDIUM VEXANS* MASSEE.

C. S. Venkata Ram and V. Jayaraman

INTRODUCTION

Co-extensive with the development of new and improved fungicide formulations, efforts have to be continuously made to provide better and cheaper control measures against plant diseases caused by fungal pathogens. Especially in foliage diseases occurring in areas subjected to continuously heavy rainfall, the demands put on protectant fungicides are rather exacting. Control of blister blight disease of tea plants, caused by *Exobasidium vexans* Massee, is a case in point. This disease attacks young foliage in the monsoon months when for the efficient control of the disease the fungicides employed have to combine a high degree of rainfastness, spreading and sticking properties with their fungitoxicity. In the investigations carried out here in the past (1, 2, 4, 9, 10), several copper fungicides have given fairly good disesae control when sprayed at intervals of 7 days. Attempts to increase the interval between applications have met with success in the case of some copper fungicides (8, 12, 15) which have given comparable disease control on 10- and 14-day rounds. However, the practical application of chemical control *vis-a-vis* blister blight disease is yet far from reaching an ideal situation. From the practical growers' point of view the emphasis is constantly on economy of both cost and time involved in the control. Operational difficulties impose restrictions where large areas are to be covered by weekly rounds of fungicide spraying and often the interval between applications increases. It is, therefore, essential to investigate 1) whether the fungicides commonly used will give satisfactory disease control when the interval between applications is increased and 2) which of the fungicides will give adequate protection at the increased interval. The experiments described in the present paper were undertaken to provide answers to these questions and several copper and organic fungicides were tested in the field trials carried out in the 1959 blister blight season. An attempt was also made to test the efficacy of systemic antibiotics against the disease.

MATERIALS AND METHODS

Particulars relating to the various fungicides employed in the trials are given in Table I. In all, fifteen different formulations were tested of which two were antibiotics, two mixture of antibiotic and basic copper, five organic fungicides and six straight copper fungicides. For the sake of convenience, the entire trial was split up into six experiments.

Table I. Particulars of fungicides tested in the Trial.

	Fungicide	Composition	Source
1.	Actidione-S	The Semicarbazone derivative of Cycloheximide, 1.57% active	Upjohn Company, Kalamazoo, Michigan, U. S. A.
2.	Actispray	Soluble tablets each containing 380 mg. Actidione (Cycloheximide)	Upjohn Company, Kalamazoo, Michigan, U. S. A.
3.	Agrimycin 500 with 35.3% copper	3% Streptomycin, 35.3% metallic copper and 0.3% Oxytetracycline	Chas. Pfizer & Co., Inc., New York, U. S. A.
4.	Agrimycin 500 with 42.4% copper	1.755% Streptomycin, 42.4% metallic copper and 0.176% Oxytetracyline	Chas. Pfizer & Co., Inc., New York, U. S. A.
5.	Captan	50% Orthocide wettabe powder	Standard Vacuum Oil Company, India.
6.	Cyprex 65-W	Wettable powder formulation containing 65% n-Dodecylguanidine acetate	American Cyanamid Company, New York, U. S. A.
7.	Glyoxide	70% dry wettable powder formulation of Glyodin	Corona Chemical Division, Pittsburgh Plate Glass Co., Moorestown, U. S. A.
8.	Orthocide 83-W	83% Captan, Wettable powder	California Spray Chemical Cie. Francaise, Paris.
9.	Phaltan 50-W	50% Wettable formulation of N-trichloromethylthiophthalimide	California Spray Chemical Cie. Francaise, Paris.
10.	Blitox '50'	Wettable powder containing 50% copper as Oxychloride	Tata-Fison (Private) Ltd., India.
11.	Copper Sandoz	Copper oxide wettable powder containing 50% metallic copper	Sandoz A. G., Switzerland.
12.	Fytolan	Copper oxychloride wettable powder containing 50% metallic copper	I. C. I. (India) Private Ltd.
13.	Kirticopper (Oxide)	Copper oxide containing 50% metallic copper	Kirti Chemical Works, Bombay.
14.	Kirticopper (Oxychloride)	Copper oxychloride containing 50% metallic copper	Kirti Chemical Works, Bombay.
15.	Perenox	Containing 50% copper as cuprous oxide	Plant Protection Ltd., England.

Experiments 1 and 2 were laid out in a field due for pruning in 1960. Four replicates, each comprising a row of 12 tea bushes, were randomized in each treatment, two treated rows being separated by a guard row of untreated bushes. Experiments 3 and 4 were similarly laid out in a field which was three years from pruning and Experiments 5 and 6 in a second year field.

The fungicides were sprayed with pressure retaining knapsack sprayers fitted with a low-volume (T-jet) nozzle at the rate of 15 gallons of the spray fluid to an acre. Spraying was carried out on the day following weekly plucking rounds either on 7- or 14- day rounds; in the case of the latter, fungicide application was made following alternate plucking rounds. In one of the treatments, fungicide was sprayed at 10- day intervals but the treated plots were plucked on 7- day rounds. Spraying was carried out in the mornings, often in light rain but was temporarily suspended during the period when the rainfall became heavy. Disease control was assessed by examination of 100 individual shoots picked at random from the entire lot of pluckable shoots obtained from each replicate plot and percentage shoots with *Exobasidium* infection in each of the treatment, mean of four replicates, is given in Tables II to VII. The efficacy of all the test fungicides was compared against a standard cuprous oxide containing 50% metallic copper

RESULTS

Experiment 1 : In this experiment (Table II) Copper Sandoz and six other fungicides were tested on 14- day spraying rounds in comparison to the standard fungicide treatment (Copper Sandoz applied at 7- day intervals). The experiment was started on May 26th, 1959 and continued till August 25. Actidione-S and Actispray at 5 and 10 ppm., Cyprex at 2 and 4 oz. per acre and Phaltan 50-W at 5.7 and 11.5 oz. per acre were ineffective in checking blister blight infection. The lower concentrations of Agrimycin 500, containing 35.3% and 42.4% copper, did not give adequate protection but the higher concentrations gave protection which was statistically the same throughout as that obtained in the standard fungicide treatment (Table II). Copper Sandoz sprayed at 14- day intervals also gave satisfactory protection against blister blight when compared to disease control obtained by this fungicide applied on 7- day rounds.

Table II. The control of blister blight achieved with antibiotics, copper antibiotic mixtures and organic fungicides when applied at 14-day intervals in comparison to control obtained with standard cuprous oxide.

Fungicides & rate of application	Spraying rounds	Percentage shoots infected on 20/7	27/7	3/8	10/8	17/8	31/8
1. Copper Sandoz, 6 oz/acre	7- day	14	26	34	20	21	47
2. Copper Sandoz, 6 oz/acre	14- day	22	39	47	24	24	66
3. Actidione, 5 ppm.	14- day	30	52	72	42	36	84
4. Actidione, 10 ppm.	14- day	23	52	63	54	37	65
5. Actispray, 5 ppm.	14- day	28	72	76	55	49	86
6. Actispray, 10 ppm.	14- day	32	61	80	62	42	78
7. Agrimycin, 2.85 oz/acre (35% Cu)	14- day	23	53	55	48	30	67
8. Agrimycin, 8.5 oz/acre (35% Cu.)	14- day	12	26	39	30	16	44
9. Agrimycin, 5.7 oz/acre (42% Cu.)	14- day	21	51	49	46	36	82
10. Agrimycin, 14.2 oz/acre (42% Cu.)	14- day	20	42	48	32	27	55
11. Cyprex 65-W, 2 oz/acre	14- day	23	57	69	47	37	84
12. Cyprex 65-W, 4 oz/acre	14- day	18	54	72	46	39	88
13. Phaltan 50-W, 5.7 oz/acre	14- day	35	70	78	61	53	91
14. Phaltan 50-W, 11.5 oz/acre	14- day	23	44	57	43	39	73
15. Control —	—	50	69	80	68	67	88
Difference required for significance P = 0.05		10	18	15	14	12	14

Experiment 2: When the antibiotics and organic fungicides, at the rates of application tested in Experiment I, failed to check the disease to any appreciable extent on 14- day rounds, their effect on blister blight when sprayed at 7- and 14-day intervals was next investigated with higher dosages of these fungicides. Agrimycin 500 containing 35.3% and 42.4% copper was tested at the lower levels, em-

ployed in Experiment I, on 7- day round applications and at high concentrations on 14- day rounds. Spraying was started on September 1st and continued till the end of November. Results (Table III) again showed that Actidione-S, Actispray, Cyprex and Phaltan 50-W were ineffective in checking the disease when applied at 14- day intervals, even at high concentration. On the other hand, the same concentration of Actispray and half the concentration of Cyprex gave adequate protection when sprayed at 7- day intervals. Although Phaltan 50-W did not give satisfactory protection even on 7- day applications, the disease control achieved in this treatment was statistically significant throughout when compared to control obtained by the higher concentration of this fungicide on 14- day round application (Table III).

Table III. Results of blister blight control with antibiotics, antibiotic plus copper mixtures and organic fungicides applied on 7-and 14-day rounds, compared to standard cuprous oxide.

Treatment & rates of application		Spraying rounds	Percentage shoot infection on					
			5/10	12/10	2/11	9/11	16/11	23/11
1.	Control Unsprayed	—	67	57	72	70	70	78
2.	Copper Sandoz, 6 oz/acre	7- day	16	19	14	18	26	22
3.	Copper Sandoz, 6 oz/acre	14- day	34	30	32	30	32	55
4.	Actidione, 25 ppm.	14- day	50	51	48	52	62	68
5.	Actidione, 50 ppm.	14- day	38	45	36	53	50	59
6.	Actispray, 50 ppm.	7- day	26	25	25	48	34	53
7.	Actispray, 50 ppm.	14- day	43	43	40	56	62	62
8.	Agrimycin, 3 oz/acre (35% Cu.)	7- day	20	23	20	25	25	33
9.	Agrimycin, 9 oz/acre (35% Cu.)	14- day	23	24	22	25	25	53
10.	Agrimycin, 6 oz/acre (42% Cu.)	7- day	23	22	22	26	36	48
11.	Agrimycin, 18 oz/acre (42% Cu.)	14- day	38	32	32	46	40	56
12.	Cyprex 65-W 6 oz/acre	7- day	22	22	21	25	30	51
13.	Cyprex 65-W 12 oz/acre	14- day	44	49	40	57	58	76
14.	Phaltan 50-W 12 oz/acre	7- day	25	33	24	32	49	54
15.	Phaltan 50-W 18 oz/acre	14- day	51	51	46	53	62	76
Difference required for Significance P = 0.05			12	11	11	12	12	16

The copper fungicides, including the copper antibiotic mixtures, gave satisfactory protection throughout on 7- day round applications. The two formulations of Agrimycin 500, one containing 35.3% at 3 oz/acre and the other 42.4% copper at 6 oz/acre, gave protection comparable to the standard fungicide treatment; at these rates of application the copper in the Agrimycins represented approximately one-third and five-sixth the amount of copper, respectively, of that in the standard cuprous oxide. At comparable rates of copper per acre Agrimycin 500, containing 35.2% copper, gave protection which was superior to that achieved with standard cuprous oxide when applications were made at 14- day intervals. On the other hand, at this interval between applications, Agrimycin 500 containing 42.4% copper failed throughout even when the rate of copper applied was approximately 2½ times that of the cuprous oxide (Table III).

In this experiment Agrimycin 500 containing 35.3% copper applied at 7-day intervals gave statistically the same protection throughout as that achieved in the standard fungicide treatment, whilst on 14-day rounds it gave the same protection in 5 out of the 6 assessments. Actispray, Agrimycin 500 containing 42.4% copper and Cyprex were the other fungicides which on 7-day, but not on 14-day rounds gave adequate protection, the disease control in these treatments being statistically the same as in the standard fungicide treatment during four out of six in the case of Actispray and five out of the six in the other two, when assessments for infection were made. (Table III).

Experiment 3: Two organic fungicide formulations, namely Captan (50% Orthocide) and Orthocide '83' (83% Captan) and two 50% copper formulations, Fytolan and Perenox, were tested in this experiment which was started on June 7. Captan at 12 oz. per acre and Orthocide '83' at 4 and 7 oz. per acre were sprayed at 14-day intervals, whereas the two copper fungicides were applied at 7-day intervals (one of these was the standard fungicide treatment). It was observed (Table IV) that both Captan and Orthocide '83' almost completely failed to check the disease as the blister blight season progressed and, therefore, spraying with these fungicides was discontinued on August 14. Fytolan throughout gave statistically the same protection as that obtained with the standard cuprous oxide.

Table IV. The results of blister blight control achieved with various concentrations of Captan (50 and 83 per cent.) applied at 14 days intervals in comparison to protection obtained by copper fungicides sprayed on 7-day rounds.

Fungicides & rates of application	Spraying rounds	Percentage shoots infected on 10/7	17/7	24/7	31/7	14/8	21/8
1. Orthocide '83', 4 oz/acre	14-day	25	30	66	86	—	—
2. Orthocide '83', 8 oz/acre	14-day	21	34	78	77	—	—
3. Captan, 12 oz/acre	14-day	31	43	81	90	—	—
4. Fytolan, 6 oz/acre	7-day	11	12	50	69	53	52
5. Perenox, 6 oz/acre	7-day	7	18	21	55	41	49
6. Control, Unsprayed	—	42	56	87	95	82	84
Difference required for Significance	P=0.05	7	13	12	16	17	19

Experiment 4: Orthocide '83' at dosages comparable to that employed in Experiment 3 were tested on 7-day rounds in this experiment, started on August 27 and continued till December 5. At both $3\frac{3}{4}$ and $7\frac{1}{2}$ oz. per acre Orthocide '83' failed to give satisfactory protection in comparison to that achieved with the standard cuprous oxide at 6 oz. per acre on identical spraying rounds (Table V).

Table V: Disease control given by Captan (Orthocide '83') on 7-day spraying rounds in comparison to standard cuprous oxide (Perenox)

Treatment	Spraying rounds	Percentage shoot infected on 9/10	16/10	6/11	13/11	20/11	27/11
1. Orthocide '83', $3\frac{3}{4}$ oz/acre	7-day	35	32	50	57	56	75
2. Orthocide '83', $7\frac{1}{2}$ oz/acre	7-day	40	30	49	61	60	72
3. Perenox, 6 oz/acre	7-day	23	19	30	27	32	47
4. Control —	—	64	65	78	74	77	83
Difference required for Significance	P=0.05	11	17	12	13	16	18

Experiments 5 and 6: These experiments were carried out on lines indicated in the earlier paper (15) to investigate the relation of interval between fungicide applications to blister blight control. In experiment 5, Blitox '50' and Perenox were tested at 6 oz. per acre on 7-, 10-and 14-day rounds (Table VI). Glyoxide at 5 oz. per acre on 14-day rounds was also included in this experiment, but spraying with this organic fungicide had to be discontinued midway because the

treated plots were blistered as heavily as the untreated control. Blitox '50' on 7-day round gave satisfactory protection throughout, comparable to that obtained with Perenox on identical spraying rounds. When the interval between applications was 10 days, Perenox throughout gave protection which was statistically the same as that achieved with spraying this fungicide at 7-day interval, but Blitox '50' failed five times out of seven to give such protection (Table VI). Disease control with Perenox applied at 14-day intervals was statistically the same as that in 7-day round spraying on four out of the seven occasions, whereas with Blitox '50' it was significantly less throughout the experiment.

Table VI. The relationship of interval between applications of copper oxide (Perenox) and oxychloride (Blitox '50') to blister blight control-Results obtained in Experiment 5.

Fungicide & Rate of application	Spraying rounds	Percentage shoots infected on 22/7	29/7	4/8	12/8	19/8	26/8	2/9
1. Blitox '50', 6 oz/acre	7-day	21	45	52	35	29	39	28
2. Blitox '50', 6 oz/acre	10-day	35	59	61	45	31	54	39
3. Blitox '50', 6 oz/acre	14-day	43	81	88	59	52	72	50
4. Perenox, 6 oz/acre	7-day	19	51	42	24	19	32	18
5. Perenox, 6 oz/acre	10-day	27	46	47	34	23	38	20
6. Perenox, 6 oz/acre	14 day	32	62	78	52	32	61	30
7. Glyoxide, 5 oz/acre	14-day	66	87	90	68	—	—	—
8. Control —	—	72	91	91	81	70	85	74
Difference required for Significance	P=0.05	15	16	14	14	16	13	12

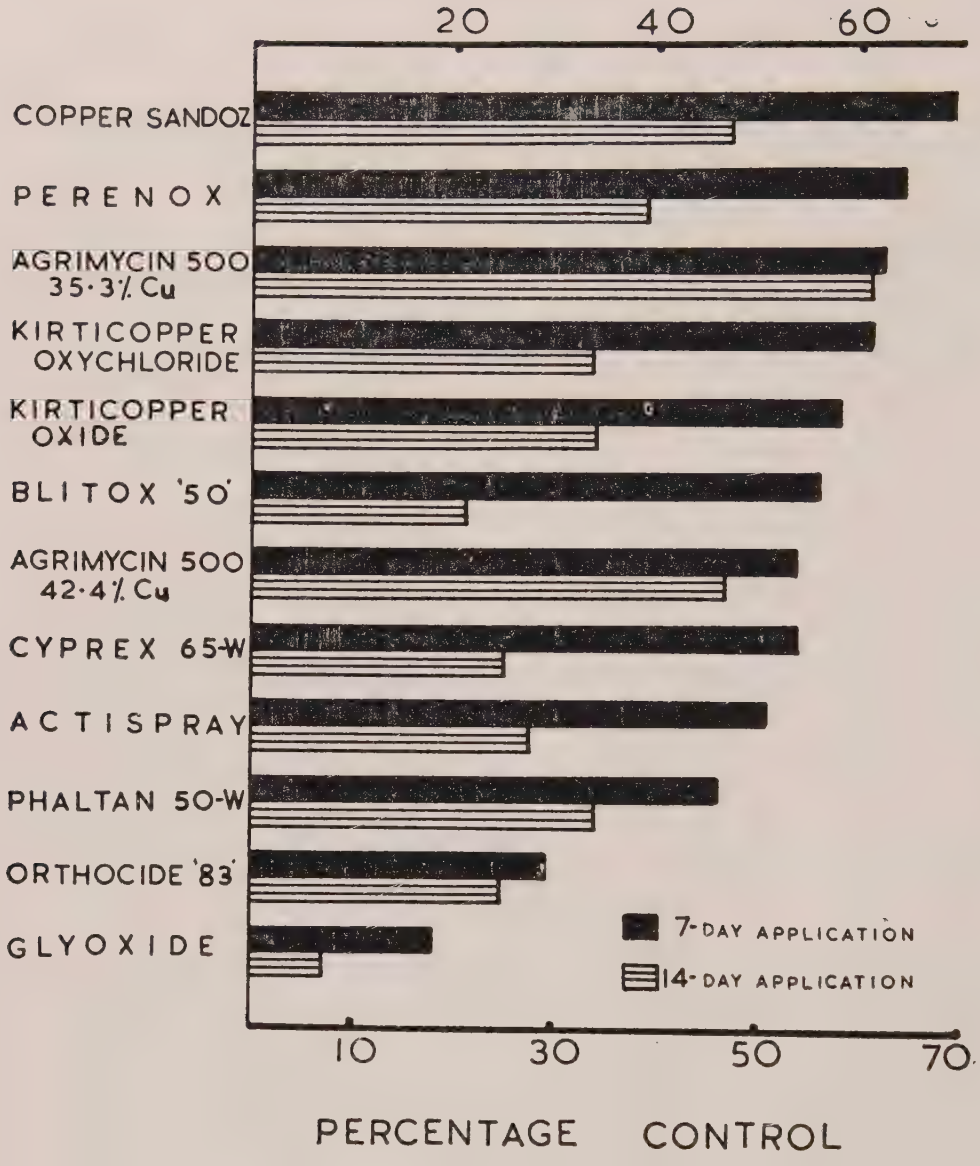
In experiment 6, an oxide and oxychloride formulation of Kirticopper, each containing 50% metallic copper, were tested at the rate of 6 oz. per acre applied on 7-, 10-and 14-day rounds. It was observed (Table VII) that both oxide and oxychloride formulations were unsatisfactory when sprayed at 14-day intervals, as compared to the disease control achieved with these fungicides on 7-day rounds. On the 10-day rounds also, the oxychloride formulation gave poor protection while with the oxide somewhat better results were obtained. Glyoxide tried again in this experiment at 9½ oz. per acre applied at 7 day intervals throughout failed to give adequate disease control.

Table : The relationship of interval between application of copper oxide and oxychloride to blister blight control - Results obtained in Experiment 6.

Treatment	Spraying rounds	Percentage shoot infection on 7/10	14/10	4/11	11/11	25/11	2/12
1. Kirticopper Oxychloride 6 oz/acre	7-day	22	16	19	29	46	45
2. Kirticopper Oxychloride 6 oz/acre	10-day	47	29	34	40	73	66
3. Kirticopper Oxychloride 6 oz/acre	14-day	52	36	56	43	69	65
4. Kirticopper Oxide 6 oz/acre	7-day	21	12	25	30	53	50
5. Kirticopper Oxide 6 oz/acre	10-day	37	25	41	32	76	66
6. Kirticopper Oxide 6 oz/acre	14-day	38	42	39	48	73	61
7. Glyoxide, 9½ oz/acre	7-day	58	52	59	59	75	70
8. Control, Unsprayed	—	69	53	80	82	91	80
Difference required for Signifiance	P=0.05	10	13	10	10	17	17

DISCUSSION

In recent years striking success has been achieved with the antibiotic Cycloheximide in the control of leaf diseases caused by basidiomycetes (6, 7, 17). In the present investigation, Cycloheximide (Actispray) and its semicarbazone derivative (Actidione-S) were tested at 5, 10, 25 and 50 ppm. against blister blight (Table II and III). Applications at interval of 14-days did not provide adequate protection, but on 7-day round spraying Actispray at 50 ppm. gave disease control in measure to that achieved with the standard fungicide treatment (Cuprous oxide containing 50% metallic copper spraying at 7-day intervals); the semicarbazone derivative of Cycloheximide was not tried on 7-day rounds. This antibiotic when applied to soil or the leaf is known to eradicate established fungal infection on the foliage and provide systemic action (5). Similar systemic action has also been reported with Captan applied either as a foliage spray against leaf disease (14) or to soil (13). However, this fungicide, applied as either 50% (Captan) or 83% (Orthocide '83') wettable powder, did not provide satisfactory blister blight control (Tables IV and V). In previous experiments also (10) Captan proved unsatisfactory in the control of blister blight. However, it gave adequate protection once when applied at the rate of 12 oz. per acre on 7-day rounds (10), but in the present trial, comparable rates of application with Captan on identical rounds gave disease



TEXT FIG. 1

giving the maximum percentage blister blight control achieved at any time during the entire trial, with various fungicides when applied at 7-and 14-day intervals.

control which was significantly lower than that obtained with the standard fungicide treatment (Table V). Phaltan 50-W, an analog of Captan, gave unsatisfactory protection when applied at the interval of 14-days but on 7-day rounds this fungicide at 12 oz. per acre gave moderate protection (Table III). A somewhat parallel behaviour to this was observed with Cyprex which also failed completely on 14-day rounds but gave satisfactory disease control on 7-day round applications (Table III). The active ingredient of all the organic formulations tested here possess excellent fungistatic properties and, therefore, their poor field performance in blister blight control is probably due to their inability to resist well the heavy rainfall experienced during the trial (rain on 23 days in June, 31 in July, 25 in August, 24 in September, 17 in October and 10 in November). Perhaps if a sticker is incorporated with these formulations, they would resist the washing action of this heavy rainfall; further investigations on these lines are being undertaken.

Previous field trials with organic and inorganic fungicides have shown the superiority of copper fungicides over the others in the control of blister blight (10, 11, 16). These findings have been confirmed by the results obtained in the present investigation (Text-fig. 1). The present results also confirm that satisfactory disease control is achieved with the application of copper fungicides at the rate of 3 oz. of metallic copper per acre on 7-day rounds (Text-fig. 1). There was no significant difference in the protection given by formulations containing 50% metallic copper, either as oxide (Perenox, Copper Sandoz and Kirti-copper oxide) or oxychloride (Fytolan, Blitox, '50' and Kirticopper oxychloride), when fungicide application was made at the same concentration on 7-day rounds. But when the interval between applications was increased to 10 or 14 days, the oxides gave better protection than the oxychlorides (Tables VI and VII). The control achieved with Perenox *vis-a-vis* increased intervals between fungicide applications indicated that it may be possible to carry out spraying on 14-day rounds without significantly increasing disease incidence, thus confirming previous observations (15). Blister blight control with Perenox applied at 14-day intervals was statistically the same as that in 7-day round spraying four times out of seven when observations were made (Table VI). Another cuprous oxide (Copper Sandoz) also gave statistically the same protection, almost throughout in Experiment 1 (Table II) and on three out of the six occasions in Experiment 2 (Table III), when applied at 7 - and 14 - day intervals. However, in a parallel experiment, the third cuprous oxide formulation tested, namely Kirticopper oxide. did not give such results. It seems plausible that the nature of the inert ingredient in Kirticopper oxide makes it unsuitable on longer rounds of application since the other formulations, Perenox and Copper Sandoz, containing identical amounts and form of metallic copper, gave satisfactory protection on longer spraying rounds. That a good cuprous oxide formulation can be sprayed once every 14-days to give adequate protection against blister blight is very indicative from these and previous (15) results.

Investigations in the last few years have clearly indicated the superiority of copper antibiotic mixtures over straight copper fungicides and antibiotic alone in controlling certain fungal leaf diseases (3, 18). When neutral copper was supplemented with streptomycin, the antibiotic synergized the action of copper resulting in improved performance of the fungicide (18). Agrimycin 500, tested in the present investigation, contains basic copper, streptomycin and oxytetracycline in synergistic combinations, the one having 35.3% metallic copper and larger concentrations of the two antibiotics being superior to the other having 42 4% copper and lower antibiotic content (Text-fig. 1). Even on 14 – day round applications, Agrimycin 500 (containing 35.3% copper) gave protection against blister blight in measure to that given by cuprous oxide on 7 – day round, at 3 oz. of copper applied per acre (Table II). This formulation of Agrimycin 500 gave protection superior to that achieved with cuprous oxide, at comparable rates of copper per acre, when applications were made at 14 – day intervals (Tables II and III). At approximately one-third the copper per acre (1 oz.) Agrimycin 500 gave statistically the same protection as achieved in the standard fungicide treatment (3 oz. copper per acre) when both were applied at 7 – day interval (Table III). It is relevant to state here that similar protection with approximately one-third the normal rate of copper application per acre has also been achieved with colloidal copper formulations (9, 10). Nonetheless, insofar as preference to longer spraying rounds is to be given in any programme of blister blight control, the potentiality of Agrimycin 500 and a good cuprous oxide formulation, as for example Perenox and Copper Sandoz, will put these as fungicides of choice.

SUMMARY

1. Field tests were made in 1959 with 2 antibiotic formulations, two antibiotic and basic copper mixtures, six straight copper fungicides and five organic fungicides for their comparative efficiency in controlling blister blight at various intervals and rates of application.

2. Neither the antibiotic (Cycloheximide and its semicarbazone derivative) nor any of the organic fungicides (Captan, Cyprex, Glyoxide, Orthocide '83' and Phaltan) gave satisfactory disease control when applied at 14 – day intervals, at the rates tested. Two cuprous oxide, but none of the copper oxychloride, fungicides and antibiotics plus basic copper formulations (Agrimycin 500, containing 35.3% or 42.4% copper) gave adequate protection on 14 – day rounds.

3. When the fungicides were sprayed at weekly intervals, Cycloheximide (Actispray), Agrimycin 500, Cyprex 65-W and Phaltan 50-W gave satisfactory control against blister blight infection but not Glyoxide, Captan and Orthocide '83' (83% Captan). All the straight copper fungicides tested, namely Blitox '50', Copper Sandoz, Fytolan, Kirticopper oxide and oxychloride and Perenox also gave satisfactory disease control in 7 – day spraying rounds when applied at the normal rate of 3 oz. copper per acre.

4. Perenox, Copper Sandoz and Agrimycin 500 applied at the normal rate of copper per acre gave adequate protection against blister blight even when fungicide applications were made at 14 – day intervals. Agrimycin 500 containing 35.3% copper was superior to Copper Sandoz in giving protection at 3 oz. copper per acre on identical spraying rounds. The potentiality of these fungicides in checking blister blight on longer spraying rounds at the normal rate of copper per acre is indicated.

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(14) Napier, E. J., Rhodes, A., Turner, D. I., Tootill, J., and Dunn, A. (1957) Systemic action of Captan against *Botrytis fabae* (Chocolate spot of broad bean). *J. Sci. Fd. Agric. 8:* 467-474.

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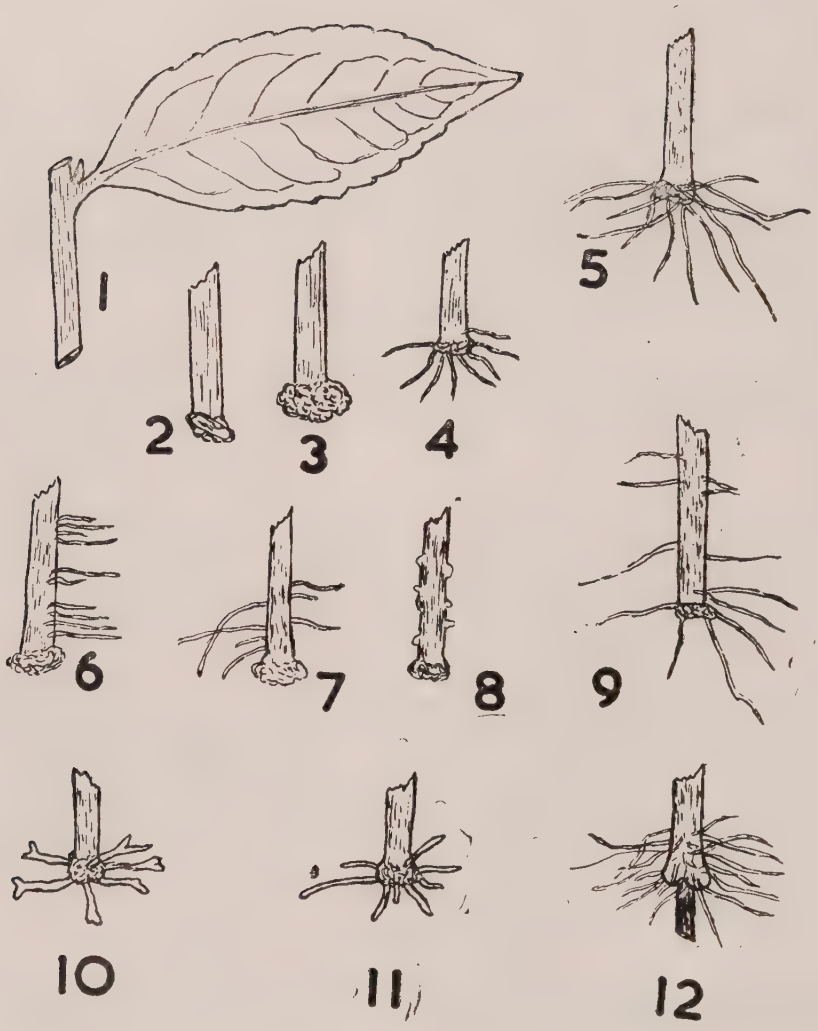

TEXT-FIGS. 1 to 12

1. A leaf and internode tea cutting. 2. Normal callus formation at the basal end of the cutting. 3. Abnormal and heavy callus formation caused by excessive moisture in the rooting medium. 4. Normal callus and root formation in clone BBRB in 12 weeks' time. 5. Root system in cutting treated with indole-butyric acid (5000 p.p.m. of IBA in 50% alcohol and quick-dip method). 6 to 9. Formation of roots all along the stem in cuttings treated with dust formulations of Hortomone A and Seradix B, especially with dusts carrying high concentrations of growth substances. 10. Short, thick and forked roots developing on cuttings treated with indole-propionic acid (1000 p.p.m. IPA, quick-dip). 11. Swelling of basal end of the cutting and development of a few thick, short and brittle roots on cutting treated with 2, 4-D (25 p.p.m., quick dip). 12. Injury caused to the basal end of the stem by 2, 4, 5-T treatment (25 p.p.m., quick dip); note thickening of the stem and development of roots above the damaged stem portion.

THE EFFECT OF GROWTH SUBSTANCES ON ROOTING OF TEA CUTTINGS

K. S. Venkataramani

Research in the field of growth regulators has made, and is making, contributions to horticulture equal to, if not greater than, any other field of endeavour at the moment. Although growth substances are now being employed for many purposes, the oldest and greatest use to which they are put to in horticultural practice is for inducing root formation in plant cuttings for propagation.

The tea bush (*Camellia sinensis* (L) O. Kuntze) is a plant of considerable economic importance to all countries where this crop is grown on a commercial basis. Attempts have been, and is being, made to improve the crop by selection and breeding. It is recognized, however, that vegetative propagation of specially selected bushes with desirable qualities is the only quick means of improving the planting stock (18) and it is now well established that propagation with "leaf and internode" cuttings is the most rapid method of multiplication. The rooting ability of the tea cutting is an inherent clonal character (18), and good and poor rooters are known. It is little wonder, therefore, that attempts have been made in all tea research centres to study the effect of growth substances on rooting of tea cuttings. Results reported so far in the literature are conflicting. Some workers have recorded definite beneficial effects of growth substances on rooting of tea cuttings (2, 4, 5, 6, 7, 8, 9, 14, 15, 16, 22, 24), while the results of some others would indicate that there is no special advantage to be gained by the use of growth substances (3, 10, 11, 12, 17, 21, 23, 25) A few workers, however, have indicated that growth substances may be beneficial under certain circumstances (13, 19, 23). Recent work in South India (20) shows that rooting of tea cuttings is influenced to some extent by treatment with growth substances. The quantity and quality of the roots formed on cuttings appears to depend on the treatment received by the cutting (Text. figs. 1 to 12). Beneficial effects, such as quicker root formation and heavier rooting, have been observed in more than one clone (unpublished data of the author) and there are indications that certain modifications in the treatments applied may result in obtaining more liftable plants in a shorter time from the treated cuttings than from the untreated ones. If this is confirmed, treatment of cuttings with a suitable growth substance can be recommended as a routine procedure to be adopted in a nursery. Detailed experiments to evaluate the roll of growth substances in the vegetative propagation of tea are in progress and it is premature to discuss the preliminary results obtained so far. However, as a prelude to a critical review of the subject, the author would now like to present an annotated list of references on the effect of growth substances on rooting of tea cuttings and it is hoped that this list will be of interest to those engaged in vegetative propagation of the tea bush.

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1. Anon, (1954)

Notes on current investigation, Research April to June 1954.

Malayan agric. J. 37 : 176 – 77.

It is stated that no improvement in rooting of tea cuttings resulted from the use of hormones. Details of the experiments are not presented in these notes.

2. Eden, T. (1941)

Report of the Plant Physiologist for 1940.

Tea Res. Inst. Ceylon. Bull *22* : 63—72.

The experiment under report explored two concentrations of Hortomone A, namely the one recommended by the makers (1 part in 320) and double that strength. Treatment was given to fresh as well as pre-callused cuttings. Two different times of immersion of the basal cut-ends in Hortomone A solution (16 and 32 hours) were also tried.

The growth substance encouraged rapid root formation. At the end of two months there was benefit of over 100 per cent. when using the stronger solution, percentage rooting in untreated control, Hortomone A 1 in 320 and 1 in 160 being respectively 30, 48 and 62. At the end of three months, cuttings treated with Hortomone A still showed a greater percentage of rooting than untreated cuttings. The longer time of immersion made little difference. Protective callusing treatment prior to application of the growth substance appeared to be advantageous (88 and 71 per cent. rooting in previously callused and fresh cuttings).

3. Eden, T. (1949)

Report of the Plant Physiologist for 1948.

Tea. Res. Inst. Ceylon. Bull *30* : 45—49.

Three grades of a growth substance in a powder form (A, B and C), intended for different degrees of hardness of the wood, were used. None of the differences in rooting of the treated and untreated cuttings was significant.

A series of 30 clones was divided into two sets, 15 good and 15 poor rooters, to ascertain whether the growth substance was effective on either taken separately. The result of this trial was also negative.

4. Eden T, (1953).

Vegetative Propagation.

A. R. Tea. Res. Inst. E. Afr. for 1952 pp. 13—26.

Eleven growth substances were tried. The results were inconclusive. 24 hours soak of the basal cut-end of the cutting in a 10 p.p.m. solution of ∝(2-methyl-4-chlorophenoxy)- propionic acid gave better rooting than in the other treatments. Of all the treatments tried, Seradix B-2 and B-3 powders gave the best survivors.

5. Eden, T. (1954)

Vegetative Propagation,

A. R. Tea Res. Inst. E. Afr. for 1953. pp. 23—29.

With quick dip and soak methods of applying growth substances, the quick dip method gave better results.

6. van Emden, J. H. (1941)

Mededeelingen inzake het stikken van thee. II

Arch. Theecult., 15 : 33—45.

The following growth substances were tried : (1) Hortomone A (1 in 240 and 1 in 480); (2) Naphthalene 1-acetic acid (45 mg./l.); (3) Indole-2-butyric acid (17 and 33 mg./l.) and (4) Indole-3-butyric acid (20 mg:/l.).

Hortomone A had the greatest effect on root formation. Rooting of cuttings was speeded up in the treated cuttings.

It was also observed that the percentage of dead cuttings varied greatly for the different treatments. The percentage of death was the lowest in Hortomone A and the highest in Indole-2-butyric acid treatments.

The vigour of the root formation was characteristic in the treated cuttings. The roots seemed to burst from the epidermis in axial rows and were usually located vertically below the leaf of the cutting. In the control series root formation always succeeded the formation of a callus tissue at the basal cut-end of the stem and the roots emerged from the callus. More roots were produced in the treated cuttings than in the untreated ones.

The combination of a pretreatment with Hortomone A and subsequent foliar application of nutrients proved very effective. The percentage rooting after 20 weeks was as follows for the different treatments.

1. Hortomone A (1 : 240) + nutrient solution = 95.0
2. Hortomone A (1 : 240) = 78.8
3. Nutrient solution alone = 22.5
4. Control = 27.5

7. van Emden, J. H. (1950)

Over de vegetative vermeerdering van de theeplant *(Camellia sinensis* var. *assamica).*

Arch. Theecult., 17 : 113 - 41

Indole-3-acetic acid, naphthyl-1-acetic acid, indole-3-propionic acid and indole-3-butyric acid were tried. Naphthyl-acetic and indole-butyric acid gave the best results. Indole-3-propionic acid was the least effective. The main effect of the growth promoting substances seemed to be the speeding up of rooting of the cuttings; more cuttings were rooted in a shorter time and at the end of a prolonged period there was very little difference in the percentage of rooted cuttings. If costly propagators are used, the growth promoting substances may increase the annual output of such a propagator. It was found to make no difference whether the chemicals were applied by the powder-method, as a concentrated dip or as a dilute aqueous solution. The powder method was found to be the most convenient for treatment of a large number of cuttings.

8. van Emden, J. H. and de Haan, I. (1939)

Voorloopige mededeeling inzake het stekken van thee.

Arch. Theecult., 13 : 75 - 85.

The following treatments were tested: (1) 16 hours soak of the basal end in heteroauxin (3-indolyl-acetic acid) solution (50 and 100 mg./l.), (2) application of heteroauxin-lanolin paste either to the basal or to the apical cut or to both, and (3) 36 hours soak in heteroauxin solution (50 and 100 mg./l.).

The 16 hours treatments and the application of lanolin paste did not stimulate root formation. The 36 hours treatments, however, showed definite stimulation of roots; 10 and 80 per cent. rooting were observed in cuttings in the 50 and 100 mg./l. series respectively whereas none of the cuttings in the control series rooted after 6 weeks.

9. Flemal, J., and Gaie, W. (1957)

Le bouturage du theier d'Assam a Mulungu.

Bull. Inf. I.N.E.A.C., 6 : 101-27.

The best rooting was obtained in 10 weeks by soaking the bases of cuttings for 24 hours in aqueous indole-butyric acid at 60-75 mg./l. Quick dip treatment with NAA at 7500 mg./l. or a 24 hour treatment with a commercial product (Rh) B, at 50 mg./l. gave promising results.

10. Gadd, C. H. (1942)

Report of the Plant Physiologist for 1941.

Tea Res. Inst. Ceylon, Bull. *23* : 58-68.

The following treatments were tried: Basal dip for 18 hours in (1) water, (2) Hortomone A 1 in 320, (3) Urea 0.15 per cent, and (4) Hortomone A 1 : 300+Urea 0.15 per cent. 50 cuttings each from 4 different clones were employed for each treatment and they were examined after 2, 3 and 4 months.

The cuttings treated with Hortomone A showed the greatest percentage of rooting after 2 months, but by the end of 4 months the cuttings treated with water only had rooted equally well. Any effect that Hortomone may have had was in speeding up slightly the rooting during the first 2 months. This effect was not apparent when Hortomone was used in conjunction with urea and urea alone was no better than the water treatment.

Hortomone A seemed to have little or no beneficial effect on the slower rooters.

11. Goodchild, N. A. (1956)

Vegetative propagation.

A. R. Tea Res. Inst. E. Afr. for 1955, pp. 23.

No significant differences were noticed.

12. Kehl, F. H. (1950)

Vegetative propagation of tea by nodal cuttings.

Tea Quart., *21* : 3-17.

The growth substances tried have not given the desired increase in rooting to justify their use for the propagation of tea. Their use results in a slight increase in rooting on average good rooters, but does not break down any inherent resistance to rooting.

The data presented are essentially the same as those discussed in reference (2) cited above.

13. Krishna, K. V. S. (1959)

Application of growth substances on clonal cuttings.

Tea Quart., *30* . 121-23.

Two growth substance formulations were tried. One was Seradix B-2 powder, a proprietary product, and the other was 'AB 8000' (4 mg. each of IAA and IBA per ml. of 50% alcohol).

During favourable months, treatment with the above growth substances gave nearly 30% increase in rooting over the untreated controls. Poor rooting clones responded markedly to treatment. For example, in clones in which the normal rooting was below 20 per cent, the increase due to treatment with growth subatances was nearly 3 to 4-fold.

14. Nakayama, A., and Harada, S. (1955)

Studies on the varietal difference of the power to form roots in the stem cutting of tea plant. (Part 2)-varietal differences of the hormone effect.

Study of Tea, 13 : 7-9.

The effect of NAA treatment was studied with cuttings from five varieties. In general, the increase in root formation due to treatment with the growth substance was related to the starch content of the cutting; the varieties which had higher starch content showed better root formation than those with lower starch content.

15. Takahashi, T. Aono, H., Morita, N., and Kunikyo, S. (1955)

Studies on the cutting of the tea plant.

Bull. Tokai-kinki agric. Exp. Stat. Tea Div., 3 : 1-27

Naphthalene acetic acid (3000 to 5000 p.p.m.) promoted rooting of the cutting. Watering the nursery bed with a solution of this growth substance was also effective. The proprietary product Rootone No. 10 was also effective in inducing root formation and the directions for its use were convenient.

16. Tubbs. F. R. (1937)

Report of the Plant Pathologist for 1937.

Tea Res. Inst. Ceylon., Bull. *18* : 44-62.

The effect of phenylacetic acid on rooting was studied. The cutting materials comprised of terminal shoots, 2 to 3 inches long bearing foliage equivalent to one medium sized leaf. In one treatment, bases of the cuttings were immersed for 12 hours in 0.1 per cent. phenylacetic acid (P) prior to planting in the rooting medium. In another treatment (PV), the cuttings were planted as in untreated control, but were exposed to vapour of phenylacetic acid throughout the experiment. The tentative conclusions of this exploratory trial were: (1) P and PV resulted in a large number of cuttings showing growth of stem and leaves at an early stage, (2) P and PV had no significant effect on the percentage of cuttings alive after 9½ months, (3) P gave a smaller percentage of successful rooting throughout. The final figures were (after 9½ months) P 7.9, PV 17.7 and control 17.2, (4) Calculating the number of plants rooted as a percentage of the total remaining alive after 9½ months, the results were : P-23.4, PV-58.1 and control 41.7, and (5) Within a week of treatment there was evidence of damage in the P series, more numerous deaths occuring in it than in the other series.

17. Tubbs, F. R. (1938).

Report of the Plant Physiologist for 1938.

Tea Res. Inst. Ceylon, Bull. *19* : 38-56

The presence of phenylacetic acid in the propagation boxes had no effect and tentative conclusions drawn in a previous trial (see reference 16 above) must, therefore, be abandoned.

The effects of a proprietary product (Seradix A) and various concentrations of indolylacetic acid (IAA) were compared. The soak method (18 to 20 hours basal dip) was adopted. The results of this trial showed that a considerably greater dilution than those tried may be necessary. There appeared to be a gradual transition from unfavourable to favourable effects upon the percentage of rooting, but up to the limit explored the results did not compare in magnitude with the differences between the rooting capacity of different clones. Results of one of the trials with Seradix A (1 in 114) indicated beneficial efiect on the gross weight of roots produced.

18. Venkataramani, K. S. (1957)

Some thoughts on vegetative propagation of tea.

UPASI sci. Dep. Tea Sect. Bull. *17* : 37-41

This paper gives a brief review of work done with growth substances.

Growth substances do not invariably assist in rooting. Different kinds of growth substances react differently. There is also an indication that all clones do not react in the same way to the same growth substance. In some trials, early callusing and rooting were noticed in the case of all treated cuttings, although the untreated ones too callused and rooted in due course. Early callusing and rooting result in a decrease in basal rot and to that extent the use of root forming substances may be beneficial. Growth substances do not substitute for good care nor do they induce rooting in these clones which consistently fail to root. Whether they are used or not, carefull attention must be paid to light, water, temperature and humidity conditions in the nursery.

19. Venkataramani, K. S. (1958)

Rooting responses of tea cuttings.

UPASI sci. Dep. Tea Sect. Bull. *18* : 52-56

Apart from a slightly earlier callusing and rooting, there is no specific advantage to be gained with the use of the commonly known growth substances in rooting of "internode" cuttings. Different types of cuttings, viz. "internode" and "leaf and node" cuttings, react differently to treatment with growth substances. While the "internode" cuttings are not generally benefited by the treatment, the cutting with a basal node are.

Earlier callusing and rooting are noticed in the case of all treated cuttings. Earlier callusing by itself is beneficial in preventing basal rot and to that extent a routine treatment of cuttings with a suitable growth substance may be recommended. Seradix B (2) powder appears satisfactory.

20. Venkataramani, K. S. (1959)

Report of the Botanist.

A. R. UPASI sci. Dep. Tea Sect. for 1958-1959, pp. 14-15.

Different growth substances affected differently not only the quality but also the quantity of the roots produced. Treatment with indole-butyric acid (IBA), indole-acetic acid (IAA), naphthalene-acetic acid (NAA) and their combinations resulted in long and fibrous roots. Thick and brittle roots and a stunted root system were produced by quick dip treatment of the cuttings with 100 p.p.m. 2,4-dichlorophenoxyacetic acid (2,4-D). 2,4,5-trichlorophenoxyacetic acid (2,4,5-T) was harmful even at a dilution of 50 p p m; quick dip treatment with this growth substance killed the tissue at that region, but callus formation and poor root development were noticed higher up on the stem. Indolylpropionic acid (IPA) produced stunted, irregular, thick and club-shaped roots. A mixture of IAA and IBA, and IBA and NAA in equal proportion (5 mg. of each per ml. of 50 per cent. alcohol) produced a greater number and dry weight of roots than IAA, IBA or NAA alone at the same total concentration (10 mg./ml.). IAA and 2,4-D suppressed the development of the axillary bud. Such a feature was not noticed with IBA and NAA.

21. Visser, T. (1958)

Report of the Plant Physiologist for 1957.

Tea Res. Inst. Ceylon, Bull. *39*: 46.

'Leaf and internode' cuttings from two clones were employed in the experiments reported in this publication. In quick dip treatments, IAA, IBA, NAA were all tried at the dilutions of 1, 2, 4 and 6 mg./ml. and GA at 2 mg./ml. of 30 per cent alcohol. Combination of IBA and NAA, and GA and IAA were also tried. Percentage rooting after 5 months were as follows: Control 21; IAA 4 mg., 40; IBA 2 mg, 38; NAA 6 mg., 42; IBA + NAA 4 mg., 42. Lower or higher concentrations and other treatments had little or no effect at all. Of the three commercial preparations (Seradix 1, 2 and 3) used, only Seradix 3 showed some effect giving 42 per cent. rooting as compared with 30 per cent. for the control.

In the powder method of treatment, eight formulations were tested, and none of the treatments gave better rooting than the control.

In the dilute solution soak method (18 hours soaking of the basal end), IAA IBA and NAA and combination of IBA and NAA at 20, 40 and 60 p.p.m., 2,4–D at 0.2, 0.4, 0.6, 20, 40, 60 p.p.m., GA at 20 p.p.m. and combination of GA (20 p p.m.) and IAA (20, 40 and 60 p.p.m.) were tested. The best results were obtained with 60 ppm. of IBA (41 per cent. rooting) and 40 or 60 p.p.m. of IBA+NAA (30 per cent. rooting) as compared with 20 per cent. rooting in the control after 5 months. The other treatments had little or no effect.

It is stated that it seems doubtful whether growth substances, even if more effective, could be efficiently used in practice as many cuttings are needed for raising plants to cover an acre. This statement applies to the dilute solution soak method, but not to the quick dip method, which is convenient for estate use.

22. Watanabe, A., and Harada, S. (1959).

The effect of slip treatment upon the root formation and growth of the tea cuttings in several varieties (Part I).

Study of Tea, 21: 1—7.

All poor rooting varieties of tea responded well to treatment with growth substances.

23. Wight, W. (1955)

Commercial propagation of *Camellia sinensis* in India.
Amer. Camellia Yearb., 1955 : 88—100.

Growth substances cause real increases in strikes when cuttings are taken at times other than those described as optimum. At optimum times they are ineffective and sometimes reduce strike. It is possible that particular clones might be benefited at any time by treatment with growth substances, but clones with all the required properties and easy to propagate without any treatment, can be found. Clones with special merit such as flavour prized by the tea blender, but difficult to root, are known and such clones might justify treatment with growth substances. It is mentioned that difficult strike, which might be overcome by treatment, is likely to be associated with short economic life and that growth substance treatment would be justified only if the value of the clone is high enough to justify a short life.

24. Wu, M. S. (1954)

An experiment on the propagation of tea bush.

Mem. Pin-Chin Tea Exp. Stat., 1 : 34—35.

Natural plant hormone (extracts of terminal buds of *Jasminum grandiflorum* L. and of roots of *Lupinus luteus* L.), and IBA and Rootone were employed in the trial reported in this paper with two varieties Ching-sin-Oolong and Tai-nan No. 29. The growth substances used in this experiment initiated root formation more effectively than the other treatments (shade and soil). IBA produced a greater number of roots on each cuttings than the other treatments. Cuttings treated with Rootone rooted more quickly than those in the other treatments. Varietal difference in response to treatment with growth substance was noticed; Tai-nan No. 29 gave a higher percentage of rooted cuttings than Ching-sin-Oolong. Jasminum extract was beneficial to Tai-nan No. 29, while lupin extract was effective with Chin-sin-Oolong.

25. Zaldastanishvilli, Sh. G. (1940)

Further notes on vegetative propagation of tea.

Soviet Subtropics, 10 : 10 – 14.

The cuttings were taken from a 12 year old plantation, woody brown shoots from the last vegetative period with 3 to 4 leaves being selected. After treatment with heteroauxin (40, 100, 200 and 400 p.p.m. for 16 to 72 hours), the cuttings were set in washed sand in a green-house with a constant temperature and sufficient air humidity. Treatment with heteroauxin at first stimulated root development, but after 7 months it was found that untreated controls gave 80 to 85 per cent. rooting as against 45 to 70 per cent. in the treated cuttings. Roots developed, however, more abundantly in the treated cuttings. Toxicity of heteroauxin increased as the concentration increased.

FUNGI CAUSING STALK-ROT AND FAILURE OF TEA CUTTINGS IN VEGETATIVE PROPAGATION NURSERY BEDS AND THEIR CONTROL

C. S. Venkata Ram

INTRODUCTION

New pest and disease problems invariably follow in the wake of new crop practices. Although vegetative propagation of horticultural plants is in vogue for the past several decades, its use in the tea industry, at least on any appreciable scale is comparatively of recent origin. The advantages of clonal selection enabling the choice of plants which give high yields and good quality tea has induced the practice of vegetative propagation more and more with tea growers in Southern India. In the past two years, however, several reports have come to light on the failure of V. P cuttings in the nursery bed and it was, therefore, deemed worthwhile investigating the causes for the failure and seeking suitable remedial measures.

In 1958, several V. P. cuttings which had failed to callus in the nursery beds were received for examination and it was observed that the bark was invariably necrosed; in certain cases necrosis had progressed to the mother leaf. When bits of the necrosed stalk were surface disinfected and cultured on nutrient agar medium, *Pestalotia theae* Sawada was isolated from the majority of the infected specimens (5). In 1959 a similar instance of failure of V. P. cuttings was again reported, but the infected stalk from these cuttings yielded *Colletotrichum camelliae* Massee in culture. Further instances of stalk-rot caused by *P. theae* and *C. camelliae* were subsequently recorded.

Another type of failure of V. P. cuttings is due to the action of certain pathogens as well as facultative fungal parasites in soil which cause root-rot. In this type of failure a normal callus is formed but when the roots start growing, the fungi (species of *Pythium, Cylindrocladium* and *Fusarium*) invade the roots and the callus, whereby the attacked tissue degenerates rapidly.

EXPERIMENTAL AND DISCUSSION

Pathogenicity tests were carried out with *Pestalotia theae* and *Colletotrichum camelliae* for their ability to attack healthy tea cuttings in soil, artificially infected with these two fungal pathogens. The fungi were increased on soil, oat-meal medium and one part of this inoculum was mixed with 19 parts of autoclaved 3 : 1 soil-sand mixture. Monoclonal tea cuttings obtained from a selected mother bush in the Experiment Station (B 34) were planted in the inoculated soil in 4 " x 1½ " glass tubes, one each per tube. Thirty-five replicates were maintained for each treatment and the cuttings were placed in a moist chamber in the laboratory.

Observations on the death of the cuttings were continued till the end of 60 days, after which the remaining ones were removed and examined for callus formation. Results are given in Table I.

Table I. Reaction of tea cuttings to Colletotrichum camelliae and Pestalotia *theae* inoculated into nursery soil.

Treatments	Percentage V. P. cuttings infected and killed after				Percentage cuttings callused after 60 days.
	15	30	45	60 days	
1. Soil arificially inoculated with *C. camelliae.*	60	80	100	100	0
2. Uninoculated soil (control for above)	0	10	10	10	90
3. Soil artificially inoculated with *P. theae* (Isolate 1)	25	50	60	75	25
4. Soil artificially inoculated with *P. theae* (Isolate 2)	15	20	30	45	55
5. Uninoculated soil (Control for treatments 3 & 4)	0	10	15	20	80

Colletotrichum camelliae was very virulent and all the V. P. cuttings planted in soil inoculated with this fungus were killed within 45 days, as compared to 90% healthy and callused in the control untreated soil (Table I). Both the isolates of *P. theae* were also pathogenic but isolate 1 was more virulent than isolate 2, the success of infection being 75 and 45 per cent, respectively. From these results it is clear that soil infection with either *C. camelliae* or *P. theae* could cause failure of V. P. cuttings. Obviously, the extent of loss would depend on the severity of infection and environmental factors accentuating the activity of the pathogen and influencing its *modus operandi.*

It is not known exactly how such fungal infection is initiated under natural conditions but the following possibilities may be considered. (1) It is well known that both *C. camelliae* and *P. theae* are capable of infecting the tender stem of tea plants (1, 3) and especially *C. camelliae* has been observed to infect the stalk of nursery seedlings (3). Therefore, any incipient infection on the shoots of the mother

bush, which may not be readily detected when the cuttings are taken, will provide potential inoculum for the initiation of stalk-rot when the cuttings are planted in the nursery soil. (2) The spores of these fungi are wind disseminated and are likely to lodge on the soil surface and if such spores come into contact with the planted V. P. cuttings, they could infect the cuttings. Investigations on other crop plants have revealed that *Colletotrichum* spores inoculated into soil by seeds carrying this fungus cause serious damage to the seedlings (4). Obviously, the parasite is capable of existing in the soil in the presence of its host of choice although it is not a soil inhabitant.

An attempt was made to investigate the response of tea cuttings to various fungicides incorporated with soil as a safeguard against stalk-and root-rot caused by fungal pathogens. A multiclonal population of V. P. cuttings was planted in nursery soil, covered with polyethylene film and shaded with two layers of coir matting. Soon after planting one ml. of a suspension of the fungicide (based on 5 lb. fungicide in 10 gallons of water) was pipetted around the stalk of each cutting and the soil watered. Thirty replicates were maintained for each fungicide treatment and for the untreated control. The experiment was run for twenty-one weeks after which the cuttings were examined and the results obtained are given in Table II.

Table II. Response of tea cuttings (multiclonal population) to fungicide treatment, one ml. of a 5% suspension to each cutting, in nursery soil; 30 replicates in each treatment.

Treatment	No. dead	No. with only callus	Number callusted & rooted.	Average dry wt. of roots in each cutting.
1. Agrimycin 35.3% copper, 3% streptomycin and 0.3% oxytetracycline)	0	8	22	96.0 mg.
2. Blitox '50' (50% metallic copper)	2	9	19	89.5 mg.
3. Cyprex 65-W (65% n-Dodecyl-guanidine acetate)	1	7	22	72.0 mg.
4. Captan (50% Orthocide)	2	4	24	107.0 mg.
5. Untreated Control	6	13	11	70.8 mg.

It is seen from the figures given in Table II that the success of rooting was higher in the fungicide treatments when compared to the control. The number of cuttings rooted in Agrimycin and Cyprex treatments was double that in the untreated control and it was more than double in the Captan treatment. The average dry

weight of roots developed in individual cuttings was also appreciably higher in three out of the four fungicide treatments, when compared to the control. Captan is known to be taken up by growing plants from the fungicide treated soils (2) and perhaps it may exert stimulating effect on plant growth.

The present results are only from a preliminary experiment and further trials with larger replicates and monoclonal population of tea cuttings will have to be undertaken to confirm these findings. Nonetheless, it seems clear from the data given in Table II that fungicide treatment immediately following planting would ensure better percentage of survival and rooting than if the cuttings are not treated, presumably by halting the action of facultative fungal parasites in the soil which cause stalk—and root-rot.

SUMMARY

1. Several instances of failure of V. P. cuttings due to fungal diseases in the nursery beds have come to light in the past two years. *Colletotrichum camelliae* and *Pestalotia theae* were isolated from the diseased stalk of such cuttings.

2. Artificial inoculation of cuttings with *C. camelliae* and *P. theae* was successful under laboratory conditions ; both the fungal pathogens produced typical stalk rot. The possibilities whereby such infection could occur under natural conditions are discussed.

3. Treatment with two organic fungicides (Captan and Cyprex), one inorganic copper fungicide (Blitox '50') and one a mixture of copper plus antibiotic (Agrimycin 500), immediately following planting, resulted in higher percentage of rooting in cuttings when compared to the untreated control, presumably by halting the action of root rotting fungal pathogens and other facultative parasites in the soil.

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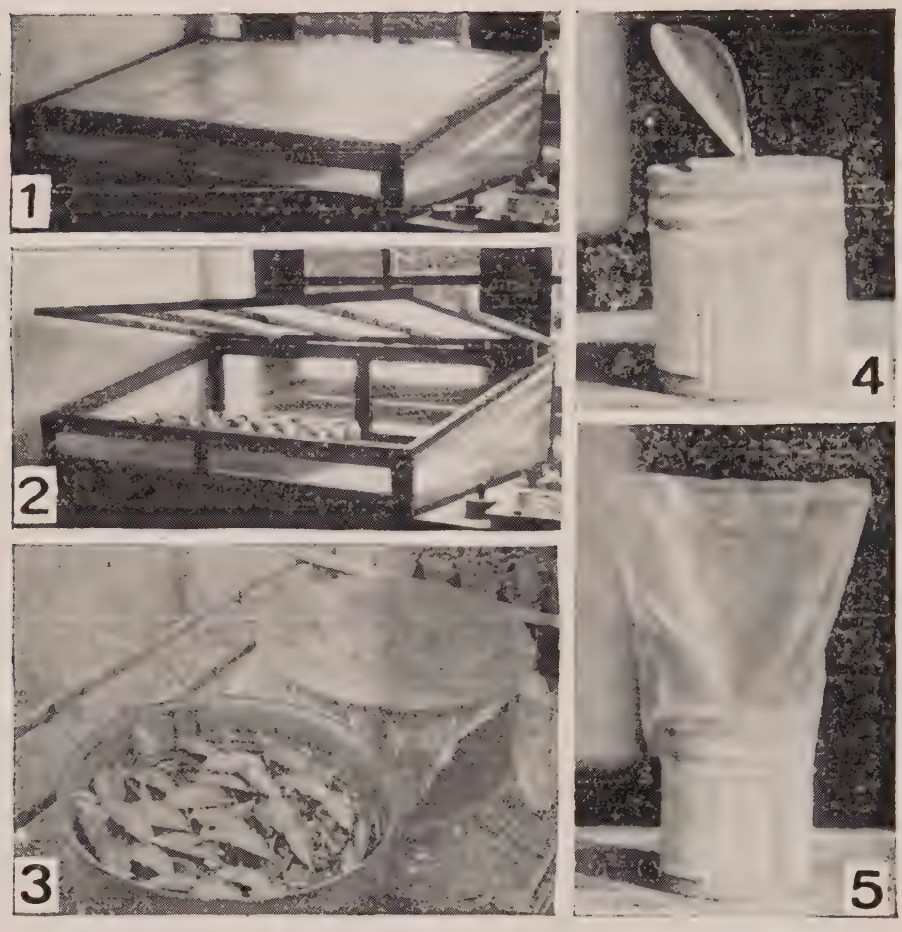

PLATE 1

Figs. 1 and 2: Propagation frames fitted with polythene film on the sides and on the lid.

Fig. 3: Propagation bins, one with a cover of polythene film and the other open showing tea cuttings.

Fig. 4: A tea cutting in a tin container.

Fig. 5: The cutting in the tin is covered over with a polythene bag which is securely tied to the tin.

POLYTHENE IN VEGETATIVE PROPAGATION OF TEA

K.S Venkataramani

Polythene (polyethylene) film, a versatile plastic material developed during recent years, is now put to several uses in agriculture (2,3,5 and 10). It has proved to be of some aid in the vegetative propagation of tea and its uses in this connection are briefly reviewed here.

The first use which polythene film could be put to is for the transport of tea shoots from the mother bush to the nursery, where individual cuttings are prepared. Moisture loss from the cut shoots and their subsequent wilting could be prevented if the shoots are inserted into polythene bags immediately they are severed from the mother bush; such packed shoots, however, should be kept in shade and not exposed to direct sun until they are transported to the nursery. It has been reported from Ceylon that cut shoots with their basal ends tied together with a wad of wetted absorbent cotton wool round them packed and sealed in polythene bags could be left for a period of about two weeks and then used for taking cuttings (4). This has been confirmed in our trials too. In fact, we have found polythene bags very handy for storing pretreated shoots for periods of three to four days before cuttings are taken from them for experimental purposes.

The second use to which polythene could be put is to cover the propagation (rooting) beds. Its unique property of preventing moisture escape while permitting gaseous exchange makes it a useful material for this purpose. In our experiments we have found that it can be safely and beneficially employed in the vegetative propagation nursery to conserve soil moisture, prevent excessive transpiration from the leaf cuttings, maintain high humidity over the cuttings, protect the soil from the beating action of rain and prevent wind damage to cuttings in the callusing beds. In addition to these advantages, cost of watering could be reduced, but more than that maintenance of an almost uniform moisture level without resorting to very frequent watering is made possible. Several methods of covering the cuttings (namely, covers to individual cuttings raised in tins, tubes or pots for experimental purposes; a sheet of polythene cover over a bin containing a batch of cuttings, a lay-flat cover over the cuttings in a bed, and frames fitted with polythene sides) have been tried successfully (Plate I), but for large scale estate work, a raised tent-like cover over the beds has been found most useful (6,7 and 8). We are, indeed, in a happy position to record here that polythene is being used on an estate in the Nilgiri-Wynaad for routine propagation purposes with considerable success. The potential use of polythene covers has also been suggested by investigators in Ceylon (9) and Malaya (11). It has been reported recently from Ceylon that the results obtained with a yellow polythene cover were better than those obtained with a transparent one (9). It is necessary to point out at this stage that proper attention should be given to shading of the nursery beds,

whether polythene is used or not, in order to prevent sunscorch of the leaves and wilting of cuttings. Shade has to be regulated carefully, especially when a polythene cover is employed; otherwise, with the high humidity and high temperature developing in the closed atmosphere over the cuttings, considerable damage may result even within a short period.

A third and novel use of this material is for packing and mailing of callused cuttings over distant places (12). Polythene makes it possible to have a light and simple pack which does not require the use of charcoal powder or any other inert matter. We have recently carried out some preliminary experiments with this type of packing and have found that the callused cuttings could be given a quick-dip treatment with a suitable growth substance (in our trials, indolebutyric acid at 10,000 p. p. m. in 50% alcohol) and stored in the laboratory for two weeks. Such pretreated callused cuttings rooted better and quicker (two weeks earlier) than untreated callused cuttings after being put out in the rooting medium. This aspect of vegetative propagation deserves further attention and if these preliminary results are confirmed, it would lead to the ease with which cuttings of selected clones could be distributed to far off places.

Polythene bags are now employed for raising seedling plants in many horticultural and forest nurseries. These bags are also being used in some tea estates in lieu of the conventional bamboo baskets for raising tea seedlings. They may be put to a similar use in a vegetative propagation nursery, provided the bags, once filled with soil and planted with delicately rooted cuttings, are not constantly handled. Indications of promising use of polythene lay-flat tubes for raising vegetative propagation nurseries in areas where suitable nursery sites are wanting are reported from Tocklai (1).

Polythene film is available in various thicknesses, but in all our trials we have found film of 150 or 200 gauge to be the most suitable.

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TEA PLANT AND CONTROL OF ROOT DISEASES, I.

In situ action of soil fungicides on *Fomes noxius*, *Rosellinia arcuata* and *Ustulina zonata*.

C. S. Venkata Ram

Disease of the tea plant caused by *Fomes, Poria, Rosellina* and *Ustulina* have a long history and some of the salient information on the mode of their attack and spread in tea soils has been early given by Petch (32). The initial infection by these fungal organisms usually takes place when their spores are disseminated by wind and lodge on the exposed surface of a recenty felled shade tree; the fungus then establishes itself by growing through the stem into the roots. Subsequently, the fungus is capable of attacking healthy roots of tea plants (i) by spreading through soil from the infected stump and (ii) by infecting those which are in contact with the diseased roots of the shade plant. Once the fungal infection is established within the soil, its eradication becomes difficult. The common measure of control practiced against these root diseases is to dig out the diseased plant and remove all the infected roots which are then burnt. Usually, the diseased area is isolated by a trench. It should be mentioned, however, that the removal of all the fungal infected plant material from the soil is not feasible and a few diseased plant debris left behind could act as potential sources of infection. The other difficulty involved in control by plant sanitation is that when root disease on tea plants is detected in the field, the fungal infection is likely to have spread from these plants to the apparentely healthy ones surrounding them. It is, then necessary, to expose and examine the root system of not only the plant which is dead, or dying, but also that of the others immediately around it. A short-cut method to obviate examining the root system of several bushes, a practice which is laborious and requires skilled knowledge for detecting fungal infection, is to include a ring of apparently healthy tea plants around the diseased one in the infected area and isolate the area by trenching. The shortcomings of the above control measures are only too obvious and attempts at providing simpler and more effective control of root diseases of tea plant have been recently made and the results of a preliminary investigation are reported here.

Volatile and non-volatile soil fumigants have long been in use in plant disease control. Among the non-volatile disinfectants sodium nitrite (14) and copper fungicides (15) have been successfully employed in the earlier years against damping off organisms in soil. Newhall (28) has reviewed the earlier work on the volatile fumigants then in common use, as for example, chloropicrin, carbon disulphide, ethylene dibromide and methyl bromide. Bliss (6) suggested injecting carbon disulpide into trenches aronnd *Armillaria* infected patches to prevent spread of the disease. Even within the past one decade the use of chloropicrin (1, 26, 35, 42, 43, 45), ethylene dibromide (26, 41) and methyl bromide (26, 27, 41, 43, 45) has

given practical control in the field of several soil-borne diseases. With the development of new and improved soil disinfectants the control of many root diseases of plants has become possible. Thus, the development of the isomers of chloronitrobenzene has given fungicides which have successfully controlled *Rhizoctonia solani* infection of potatoes (7) and cotton (24). Treatment of tomato roots with pentachloronitrobenzene (PCNB) has given systemic control against wilt caused by *Fasarium oxyporum F. lycopersici* (20). Mixed with Captan, PCNB has given promising control of seedling damping-off in cotton (36). It has been shown that PCNB is fungistatic to specific organisms (2, 38), mainly the mycelial forms, whereas it increases the population of the sporulating fungi.

Another recently developed soil fumigant which has given satisfactory control of several root disease fungi is Vapam (10, 11, 30). Injected into soil 10 days prior to sowing, Vapam has controlled wilt of potatoes caused by *Verticillium* (44). Some of the foliage fungicides have proved of value as soil disinfectants, as for instance, Captan (11) which has given good protection against *Sclerotium* root rot of sugar beet (1), *Rhizoctonia* and *Pythium* damage to cotton seedlings (24) and reduced damping-off in *Pinus sylvestris* seedling (34). The development of the thiocarbamates also brought into range a number of plant diseases which could be controlled by soil application of these chemicals (11, 19, 24, 26. 34). One of the herbicides (8) and diphenyl (25) have also been found effective in giving protection against soilborne fungal pathogens. In the present investigation the action of Captan, Chlorobromopropene, Cuprous oxide, D-D, Formalin, Nemagon, and Vapam on *Fomes noxius, Rosellinia arcuata* and *Ustulina zonata* colonized within tea roots in soil was investigated.

MATERIALS AND METHODS

Tea roots of approximately 1—1.5 cm. thickness were cut to 1" long segments washed and autoclaved in flasks. They were then inoculated with each of *Fomes noxius, Rosellinia arcuata* and *Ustulina zonata*, and after 3 weeks incubation at laboratory room temperature, the fungal colonized segments were buried in soil and treated with the test fungicide, namely Captan (50% Orthocide), 55% Chlorobromopropene (CBP), Shell D-D (mixture of dischloroprapane and dichloropylene), Formalin, Nemagon (1 : 2-dibromo-3-chloropropane), Vapam (Na N-methyl dithiocarbamate dihydrate) and Cuprous oxide (50% metallic copper content, Copper Sandoz). In the field experiment the root segments were buried 4" below the soil surface in 4' x 4' plots and immediately treated as follows: 4 ml. each of D-D, CPB and Nemagon injected at a depth of 8" at 6" spacing followed by watering with 4 gallons per plot, formalin applied as drench at the rate of 1 gallon of 1% solution per square foot, drench with 10 gallons of a suspension each of Captan and Cuprous oxide containing 12 oz. of the fungicide. In the pot trial the roots colonized by the three fungi were buried in soil in 8" x 6" earthernware pots, six in each pot at a depth of 2" below surface and immediately treated with the fungicides. Nemagon, D-D,

CBP and Vapam were injected at 3" depth in 4 equally spaced holes, 4 ml. in each hole and followed by watering to saturation, whereas formalin (1% solution) and Captan (0.75% suspension) were applied as drench. After incubation for various periods, 20 root bits from the untreated control and from each of the fungicide treatments were removed, steeped in tap water, surface disinfected with 1 : 14 calcium hypochlorite for 20 minutes, washed thoroughly with sterile water and divided into two lots. One lot of root segments was immediately plated on potato sucrose-agar medium while the other lot was incubated in moist chamber under aseptic conditions and subsequently cultured on 2% agar. Observations on the fungi growing out of the segments were continued till the end of 10 days.

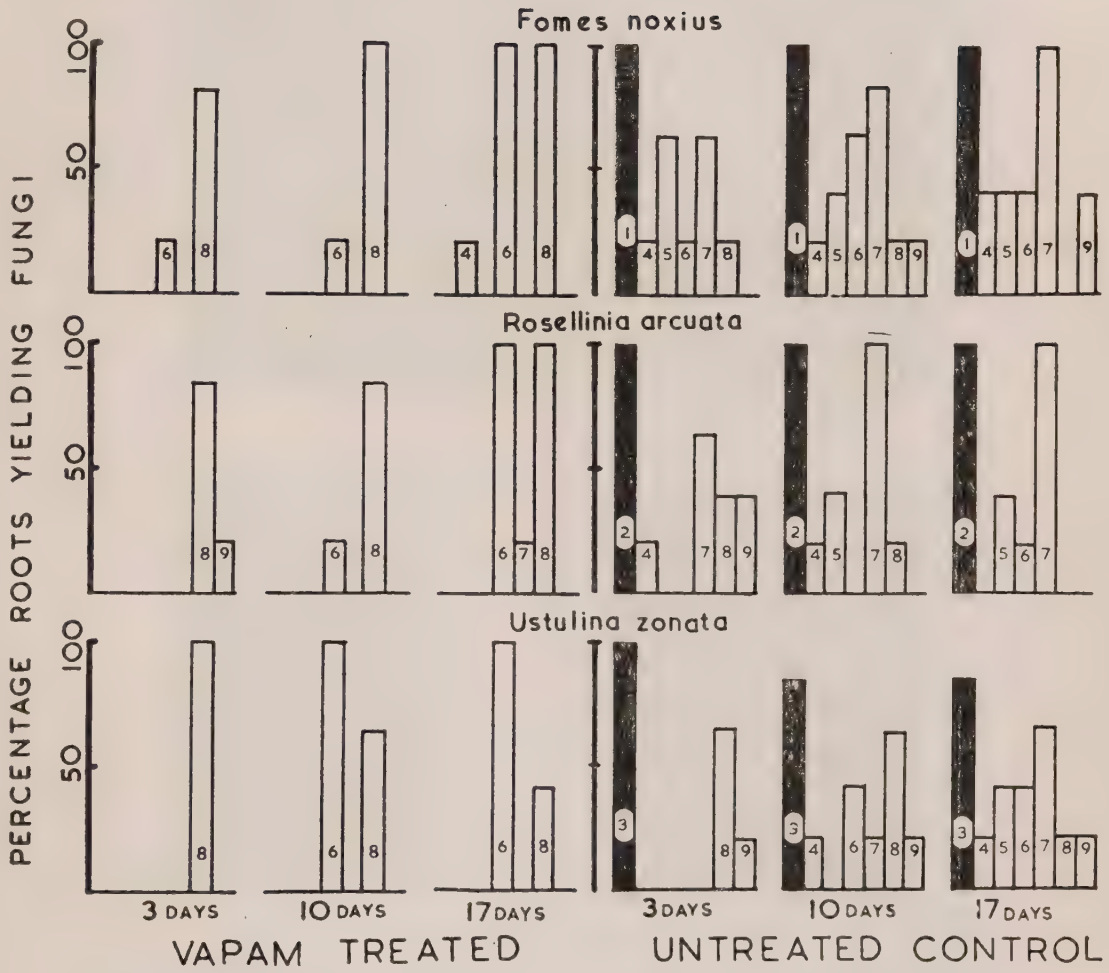
RESULTS

Results of observation on the fungi isolated from root segments previously inoculated with *Fomes noxius*, *Rosellinia arcuata* and *Ustulina zonata*, removed from fungicide treated and untreated soil in the field after 30 and 45 days are given in Tables I and II.

Table I. shows percentage root segments, previously colonized by *Fomes noxius*, *Rosellinia arcuata* and *Ustulina zonata*, and buried in soil in the field treated to various fungicides, from which the fungi were recovered in culture.

Fungicide	Percentage root segments yielding the fungi after 30 and 45 days					
	Fomes noxius		*Rosellinia arcuata*		*Ustulina zonata*	
	30	45	30	45	30	45
Shell D-D	0	0	0	0	0	0
CBP 55%	0	0	0	0	0	0
Formalin	0	0	0	0	0	0
Nemagon	0	0	0	0	0	0
Captan	60	60	90	85	60	60
Copper Sandoz	70	60	100	80	60	85
Control	80	60	100	90	65	60

It was observed that soil treatment with D-D, CBP, Nemagon and Formalin resulted in complete elimination of *Fomes noxius*, *Rosellinia arcuata* and *Ustulina zonata* colonized within tea roots buried in the soil (Table I). On the other hand, treatment with Captan and Copper Sandoz (Cuprous oxide) was ineffective in eradication of the fungi resident in the plant tissue. All the three root infecting fungi were viable within the artificially inoculated root segments for 45 days in the untreated soil and in that treated with Captan and Copper Sandoz. Several saprophytic fungi



TEXT FIG. 1

showing percentage root bits, previously inoculated with *Fomes noxius*, *Rosellinia arcuata* and *Ustulina zonata* and buried in soil treated with Vapam and in untreated soil, yielding different microorganisms when removed from soil and plated 3, 10 and 17 days after burying in soil. (1) *F. noxius*, (2) *R. arcuata*, (3) *U. zonata*, (4) *Trichoderma viride*, (5) *Cylindrocladium* spp., (6) *Penicillium* spp., (7) *Fusarium* spp., (8) Bacteria and (9) Other fungi.

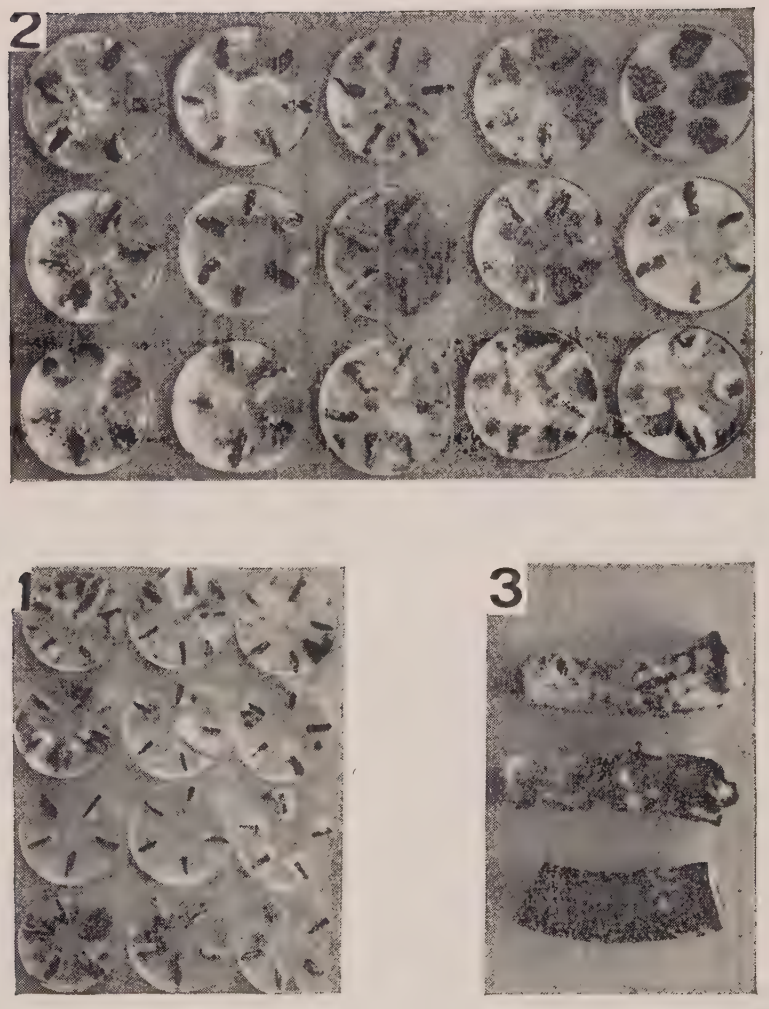


PLATE 1.

Fungi growing out of tea root bits (Fig. 1) previously inoculated with *Fomes noxius* (left row), *Rosellinia arcuata* (middle row) and *Ustulina zonata* (right) buried in pots in soil treated with shell D-D (top), Nemagon (second), Vapam (third) and Untreated (bottom row), removed after 10 days; fungi growing out of bits previously inoculated with *F. noxius* (top), *R. arcuata* (middle) and *U. zonata* (bottom row) and buried for 30 days in field in plots, untreated (left), and treated with Captan second, Formalin (third), Nemagon (fourth) and C3P (fifth row), are shown in Fig. 2. In Fig. 3 the root bits were inoculated with *R. arcuata* and buried in soil, untreated (top) and treated to Captan (middle) and Vapam (bottom); note the abundant growth of *Rosellinia* mycelium in the root buried in untreated soil, whereas no mycelium is seen growing in the root buried in soil treated with Vapam when the root segments were removed from soil after 3 days and placed in a humid chamber.

and bacteria were isolated from the roots and these sometimes tended to crowd out and mask the growth of the primary pathogen colonizing the root in the nutrient agar culture. However, the growth of the primary pathogen was invariably detected when the root segments were incubated in a moist chamber (Plate I, 3) and subsequently cultured on plain 2% agar. The figures given in Table I indicated the percentage root segments from which the pathogens were isolated when the segments were incubated in aseptic humid chambers and thereafter cultured on 2% agar and the fungi reinoculated on nutrient agar for identification.

Table II. shows percentage root segments previously inoculated with *Fomes noxius*, yielding different fungi when removed from field soil 30 and 45 days after treatment with various fungicides.

Fungicide	Percentage root segments yielding different fungi after 30 and 45 days											
	Tricho-derma		*Cylindro-cladium*		*Peni-cillium*		*Fusarium*		Bacteria		Other Fungi	
	30	45	30	45	30	45	30	45	30	45	30	45
D-D	60	60	0	0	0	0	40	60	10	0	0	20
CBP	40	80	0	0	0	60	20	0	60	35	80	60
Nemagon	80	100	0	0	0	0	40	80	0	0	0	20
Formalin	80	80	0	0	0	60	0	0	10	0	0	20
Captan	20	40	0	0	0	60	40	20	20	0	0	0
Copper Sandoz	60	40	40	20	0	40	60	40	20	0	2	20
Control	60	40	80	80	0	60	60	60	10	0	20	20

With minor differences, the bacteria and fungi invading the root segments colonized by *Fomes noxius, Rosellinia arcuata* and *Ustulina zonata* was similar in all the fungicide treatments (Plate I). For the sake of brevity, the results of isolation from *F. noxius* inoculated roots only are given in Table II. It is seen that bacteria, *Trichoderma viride* and species of *Fusarium* were the primary colonizers, being invariably isolated from the roots after 30 and 45 days. *Penicillium* spp. were isolated when the roots were cultured 45 days after fungicide traatment but not after treatment for 30 days. *Cylindrocladium* spp. were isolated from 20 – 40% of the root segments in the cuprous oxide treatment and from 80% segments in the untreated control but not in the case of the other fungicide treatments. Nemagon, CBP and formalin seemed to increase the growth of *T. viride* in soil.

Table III gives the results of percentage recovery of the three pathogens from pre-colonized root segments buried in soil in earthenware pots and treated with fungicides. In this experiment the fungal inoculated root bits were incubated for

short lengths, namely, 3, 10 and 17 days, in the fungicide treated soil. As in the previous experiment, six fungicide treatments and untreated control series were run but Vapam was introduced in lieu of Copper Sandoz. It was observed that none of the root segments inoculated with *F. noxius*, *R. arcuata* and *U. zonata* yielded the fungus even after 3 days exposure in soil to Shell D-D, CBP, formalin and Vapam (Table III). In contrast to these fungicides, soil treatment with Nemagon and Captan did not completely eradicate the pathogens resident in the tea roots when these were incubated in the fungicide treated soil for 3, 10 and 15 days. Results obtained on the recovery of the pathogens in the case of Captan treatment ran parallel to those achieved in the untreated control.

Table III. shows the percentage recovery of *Fomes noxius*, *Rosellinia arcuata* and *Ustulina zonata* from pre-colonized root bits removed after 3, 10 and 17 days from soil treated with various fungicides.

	Percentage Root Bits yielding the Fungi after 3, 10 and 17 days								
	Fomes noxius			*Rosellinia arcuata*			*Ustulina zonata*		
	3	10	17	3	10	17	3	10	17
CBP	0	0	0	0	0	0	0	0	0
D-D	0	0	0	0	0	0	0	0	0
Formalin	0	0	0	0	0	0	0	0	0
Vapam	0	0	0	0	0	0	0	0	0
Nemagon	65	60	20	100	80	45	60	40	25
Captan	100	85	80	100	100	100	85	80	80
Control	100	90	80	100	100	100	90	85	80

Only bacteria were isolated from the roots, precolonized by *F. noxius*, removed from soils treated with CBP, D-D, formalin and Vapam, (in addition also a small percentage of *Penicillium*) after 3 days' incubation (Table IV). In the D-D and formalin treatments, the bacteria in the roots were displaced by *Trichoderma viride* following further incubation in soil, whereas a large percentage of them still contained bacteria in the CBP, and Vapam treatments at the end of 10 (Plate 1, 2) and 17 days' incubation (Table IV). As is seen in Text-fig. 1, marked qualitative as well as quantitative differences existed in the fungal flora isolated from the pre-colonized root segments in the Vapam treatment when compared to the untreated control. Species of *Fusarium* colonized a large percentage of the roots in the untreated soil within 3 days' and these results are in line with the established status of this genus as a 'primary colonizer' in the soil habitat. In the Captan and Nemagon treated soils also, it was observed that Fusaria colonized a large percentage of the roots (Table IV).

Table IV. shows percentage root segments previously inoculated with *Fomes noxius* yielding different fungi when removed from pots 3, 10 and 17 days after soil treatment with various fungicides.

Fungi isolated	Incu-bation	Fungicides						
		CBP	*D-D*	*Formalin*	*Vapam*	*Nemagon*	*Captan*	Control
T. viride	3	0	0	0	0	0	10	5
	10	0	100	100	0	10	45	10
	17	80	100	100	20	20	60	25
Cylindro-cladium spp.	3	0	0	0	0	0	0	60
	10	0	0	0	0	0	0	65
	17	0	0	0	0	40	0	60
Penicilium spp.	3	0	0	0	20	0	0	10
	10	20	0	0	20	0	25	55
	17	40	0	0	100	60	30	40
Fusarium spp.	3	0	0	0	0	60	40	60
	10	0	0	0	0	80	65	80
	17	10	45	0	0	80	40	100
Bacteria	3	65	100	100	80	40	60	15
	10	80	20	20	100	20	20	10
	17	40	0	0	100	10	10	0
Other Fungi	3	0	0	0	0	10	15	10
	10	15	0	0	0	0	10	15
	17	10	0	0	0	0	10	10

DISCUSSION

From the foregoing results it would, then, appear that the elimination of *Fomes noxius*, *Rosellinia arcuata* and *Ustulina zonata* from within colonzied tea roots in soil is possible by treatment with certain fungicides, most promising of them being Vapam, 55% CBP, D-D and formalin (Table I and III). Vapam was particularly effective insofar as its fungitoxic action was concerned, the root segments buried in soil treated with this fumigant containing a high percentage of bacteria and few fungi, when compared to the other treatments, at the termination of the experiment (Table IV). Nemagon gave promising results in the field (Table I) in eradicating the three pathogens from within tea roots buried in soil treated with this fumigant, but in the pot trial it did not give satisfactory control (Table III). Treatments with Captan and Copper Sandoz were ineffective, both in the field and in pot trials. The inefficacy of those two fungicides in eradicating *F. noxius*, *R. arcuata* and *U. zonata* colonies from within infected plant roots in the soil may

be attributed to their lack of penetration, unlike the other fumigants employed in the present experiments. Captan has been found effective against several soil-borne plant pathogenic fungi (1, 11, 24, 34, 36) and it combines its fungistatic properties with low phytotoxicity. Similarly, copper fungicides have controlled species of *Pythium*, *Rhizoctonia* and *Fusarium* in soil (5. 15, 17, 29) Perhaps these two non-volatile fungicides, as also the salts of mercury which again give control of root-infecting fungi in soil (16, 39), are capable of successfully checking the activity of the naked fungal mycelium in the soil and may not influence the mycelium colonized in plant tissue, as the present results indicate. It was interesting to observe that Captan, as also the other soil fumigants, completely inhibited the colonization of *Cylindrocladium* species on the buried root segments (Tables II and IV); this fungus on the other hand, colonized a large percentage of the roots in the untreated soil.

Formalin has been among the first to be successfully employed as a soil fumigant for controlling soil-borne plant pathogenic fungi and it has given control of several diseases (1, 3, 22, 33, 43). However, this chemical cannot be applied in a field under standing crop because of its phytotoxicity. A similar situation exists with D-D mixture which has also proved effective against many soil pathogens (4, 9, 22, 23, 31, 37) and chlorobromopropene which is known to control *Sclerotium rolfsii* (21), *Verticillium albo-atrum* (42), *Pythium* sp., *Rhizoctonia* sp., and *Thielavia basicola* (43). Both D-D and CBP gave as good results as formalin in eradicating *Fomes noxius*, *Rosellinia arcuata* and *Ustulina zonata*, at the concentrations tested. Previous investigations have also given similar success of eradication of *Fomes noxius* colonizing tea roots by D-D application to soil (40). But the application of these fumigants in tea fields may not be feasible if they present phytotoxic hazards to the living plants. On the other hand, tests carried out by the author (unpublished data) indicate that Vapam when applied to field under standing tea at the rate of 30 gallons per acre, and when injected around single bushes at the rate of 75 ml. per bush, was not phytotoxic to mature tea bushes. Vapam has, in the present experiment, successfully eradicated the three main root disease pathogens of tea plant when the fungal inoculum was present within the host tissue in soil (Text. fig. 1, Table III). In previous work Vapam has been found to be very effective in reducing fungal population in soil (13). In tests on 29 recommended soil fungicides, Vapam was equal to Chloropicrin and methyl bromide and superior to the others tested against *Pythium* sp., *R. solani* and *F. Culmorum* (11). The threshold fungitoxic concentration of Vapam against 25 different soil fungi has been found to range from 50-500 ppm. (10) and the duration of its fungitoxic action has been found to be not more than 3 days under ordinary conditions (12).

Considering the practical application of the present results it would, then, seem possible to eradicate foci of infection in tea fields, under standing tea, by injecting Vapam into the soil in the infected area. This could be achieved by first pulling out the diseased tea (or shade) plant and injecting the fumigant at various

depths all around the position occupied by the diseased plant. If such a treatment ensures complete success of eradication of the tea root disease fungi from soil, its obvious advantages are likely to off-set the cost involved in the chemical treatment. The point to be emphasized, however, is that at present there is no method by which potential root disease inoculum could be eradicated from soil as the only method now available of digging out every bit of infected tissue cannot ensure complete elimination of the inoculum. In annual crops control of root diseases is often possible by following and crop rotation but in the perennial crops, apart from the sanitation measures which are at the best only prophylactic and seldom ensuring complete success, control of soil-borne diseases can perhaps be achieved only with soil fumigants. A chemical possessing potentialities for knocking out inoculum of root infecting pathogens colonized on the host, in conjunction with plant safety, will fill in a long standing gap existing in the practical control of root diseases in perennial crops. If the present results on Vapam are confirmed in further trials, now under way, the chemical control of soil-borne diseases in the field under standing crop may well become a reality.

SUMMARY

The action of Chlorobromopropene (CBP), D-D, formalin, Nemagon, Vapam, Captan and Cuprous oxide on *Fomes noxius*, *Rosellinia arcuata* and *Ustulina zonata* colonizing tea roots was investigated in field and pot trials. CBP, D-D, formalin and Vapam, but not Captan and Cuprous oxide, were effective in eradicating the fungal mycelium resident in the host tissue. Results obtained with Nemagon were inconclusive. The application of chemical fumigants in field under standing crop has hitherto not been feasible because of phytotoxic hazards. However, results with Vapam indicate that even at high rates of application at which the fumigant is lethal to a number of soil fungi, it is not phytotoxic to mature tea plants. Its use against tea root diseases in the field is indicated.

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